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Forthcoming Events.

OCTOBER 21-30.
International Motor Exhibition at the Olympia, London, W.

OCTOBER 22.
Junior Institution of Engineers:—Lecture in London. "Boiler Accidents." Paper by R. H. Kenyon.
Institute of Metals (Sheffield Local Section):—Conjoint meeting, at Sheffield, for the Sorby Lecture, by Professor H. C. H. Carpenter, F.R.S.

Institute of British Foundrymen.

OCTOBER 23.
Wales and Monmouth Branch:—Ordinary meeting at Cardiff. "Pressure Feeding of Castings," Paper by Ben Hird.
Lancashire Branch (Junior Section):—Ordinary meeting at Manchester. "The Story of Foundry Metals," Paper by T. Makemson.
Newcastle and District Branch (Junior Section):—Joint meeting at Newcastle-on-Tyne.

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Furnace Hearths and Sand Moulds for Cast Iron.

An American investigator has recently appreciatively referred to a comparison which we drew in this column when dealing with "hot spots" between the feeding of steel ingots and those portions of sand moulds which act as feeding heads because of superheating by the passage of a quantity of metal or by being heated on more than one side. We believe that it is also interesting to compare the behaviour of steel furnace hearths with sand moulds. When making steel by the open-hearth or electric process, on either an acid or a basic lining, an unpleasant phenomenon appears from time to time, which is known as a "boil off the bottom." The effect is such that the ebulition may be a foot or more in height, and unless it is rapidly checked the liquid metal may pierce a hole in the hearth and be lost. On cleaning the furnace, a cavity is invariably disclosed, and great pains are taken to rid it of every pound of metal before refilling with refractory material, otherwise subsequent remelting would dislodge the repair.

Most steelmakers assume that there exists between the container and liquid steel an equilibrium which if rudely disturbed causes a violent agitation of the metal accompanied by a heavy evolution of gas. In the case of a "boil off the bottom," this equilibrium undergoes a local disturbance, when a portion of the hearth becomes detached, by bringing the metal in contact with relatively colder material, having, because of its looser texture, a larger surface for reaction.

To our mind parallel conditions are created when liquid cast iron or steel erodes a portion of a sand mould. When due to "soft" ramming, the metal "boils" off a material offering a much larger surface for reaction, and apart from the actual "scab" produced, it renders the adjacent metal gassy. There is much to be said in favour of very smooth-faced moulds, as *ideal* smoothness is synonymous with a minimum surface area exposed for reaction, especially when doubt exists as to the reliability of the final dressing. With the chairman of the Lancashire section of the Institute of British Foundrymen (Mr. S. G. Smith) we, too, would revel in a cinematographic X-ray portrayal of the behaviour of liquid metals when entering various types of sand moulds, but the experts hold out no hope of its accomplishment in the near future.

Our analogy between "scabs" and "boils off the bottom" can be taken a little further. Very often an inexperienced melter mistakes a "boil" off a large piece of relatively cold scrap for a "boil off the bottom"—it is so similar in effect. So too a chaplet can, even if it has not attracted to itself condensed moisture or become rusty, cause a local disturbance for no other reason than that the difference in the temperature conditions (not temperature per se) between the liquid metal and chaplet is beyond "equilibrium" range artificially established by practice for the use of this metal with sand moulds.

John Wilkinson Memorial Medal.

Recent references to this silver medal have appeared in our columns, and we have pleasure in giving some fuller information regarding it and the method of its award. At the time of the Paper read to the Lancashire Branch by Mr.

Fig. 1.—A Wilkinson Token Coin, from Prof. Turner's Collection.

J. Philips Bedson, on the subject of the life and work of the great pioneer iron master, who has been called very appropriately the "Father of the British Ironfounding Trade," it was announced that a donor had been found for an annual medal to be awarded to a selected member of the junior section of the Institute being conducted by the branch in Lancashire. The gentleman who had so generously come forward at the invitation of Mr. J. G. S. Primrose was Mr. J. Thewlis Johnson, of the well-known firm at the Bradford Iron Works, in Forge Lane, Manchester, and the handsome silver medal presented annually is awarded by a special examination committee, who adjudicate the award either upon a Paper submitted at an open session of the Junior Section meetings, or, as has been the case in the last two sessions, upon a written examination paper set by the committee before the close of the session.

The method of setting the examination paper is upon the most approved lines, which takes chiefly into account the knowledge of the candidates upon such varied branches of the subject as iron-founding, pattern-making, non-ferrous metal founding, general metallurgy, and pattern-making, in all of which branches the examinees have to answer questions. Two of the sections must be dealt with completely, and two

Fig. 2.—The Wilkinson Silver Medal, based on a Coin from Mr. Pringle's Collection.

questions attempted in each of the other three. As this would involve a great deal of writing in the usual form of examination, it is arranged that each of the questions is provided with the answers which are possible to apply to it. Of course, of the three supplied by the examiners in each case, there is only one fully correct, and this is the one which must be selected by the candidate if full marks are to be attained by the placing of a cross against it. If mere guessing is tried, then disaster follows, for the chances are two to one against picking the right one without the requisite knowledge, which, however, makes the selection a comparatively easy one. Even in cases where exact numerical values are required, it is only possible to mark the right one by performing the calculation, as here again guessing is penalised. In this way the matter of facile expression is not given undue credit, nor lack of easy writing penalised. Moreover, there can be no dubiety about the correctness of the answer supplied; the work of deciding is performed beforehand, and the correction of the papers becomes a mere mechanical performance, assisted by a perforated stencil to count the crosses in the right place and award marks accordingly.

As a rule, the results are very high in average, and show the advantages of a wide grasp of elementary principles involved in the work in which they are engaged, brevity not always being the worst fault.

Design of the Medal.

It is of interest to note that the design upon which the memorial medal is based was an actual token coin issued in 1796 by the famous iron master with which to pay his workmen. A few of these, both in silver and copper, are known to collectors of tokens and coins throughout the country, but it was only so recently as last year

Fig. 3.—The Reverse of Fig. 2.

that one of these was made available through the courtesy of Mr. Jas. Pringle, of Cambuslang, to the designers of the present medal. On the obverse of the medal, as shown in the accompanying illustration, appears the head of John Wilkinson, and on the reverse is the symbolical figure of a smith beating a piece of metal upon a classical style of anvil, with, in the background, the hull and masts of a ship, typifying the construction of the first iron boat as used by Wilkinson for the conveyance of fuel for his blast furnaces, in the district near Coalbrookdale, at which the first cast iron bridge was erected at his instigation. The medal bears the two dates indicating the birth and death years of the iron master.

Another interesting form of the Wilkinson token coin, received subsequently through the courtesy of Professor T. Turner, and here reproduced photographically, has the reverse of the coin depicting a smith at work in what was a modern forge in 1793, the date of issue. The straight hearth is very clearly indicated for so old a specimen, and the metal on the anvil is being worked by the aid of the old-fashioned tilt-hammer, usually driven by water power. This form is more practical than symbolical, and thus had not the merit of being acceptable for the design of a memorial medal, which is intended to commemorate the example of the forceful and progressive iron master, who put such great faith in the uses and universality of application of cast iron.

Heat and Scale Resisting Cast Irons.

By Oliver Smalley, New York City.

(*Continued from page* 336.)

PART III.—SCALE-RESISTING CAST IRONS.

The lack of information on cast iron to withstand high temperature under oxidising conditions, its uncertainty in service, and the encroachment of costly heat-resisting alloys into the cast iron field, is the justification for reference to this phase of the subject.

White Iron Castings.

White irons made in the cupola, open hearth, or electric furnace are comparable, provided fundamental conditions of melting are observed and practised. The cupola furnace which manufactures at the lowest cost is most widely favoured. The abuse of this simple metallurgical unit, and the tendency to operate without adequate metallurgical control, however, are responsible for difficulties of control of composition, of temperature effects, of unsoundness, and of such variation in the quality of the finished product, that the immediate monetary advantages of any reduced cost of the molten metal must needs be considered in relation to the ultimate life of the casting in service.

The mechanism of breakdown of ordinary white iron under heat oxidising conditions proceeds as

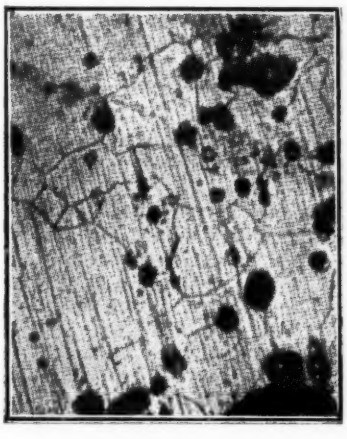

Fig. 6.—Photomicrograph of Iron Treated with Graphite Carbon, Having Burned Away, leaving Large Cavities.

follows:—(1) Dissociation of the carbides; (2) loss of carbon at surface; (3) oxide formation at surface; (4) migration of carbon from centre to surface; (5) growth of the iron by repeated heating and cooling; (6) loss of carbon from centre; (7) penetration of oxide between adjacent crystal grains; and (8) formation of oxide cavities and collapse.

Were it not that this breaking-down process eliminated the natural brittleness and fragility, white iron would lose much of its serviceable value for high-temperature work; hence malleability, although indicative of the first stage of collapse of the iron under heat influences, is a necessary property gained only at the expense of an equally important one— viz., resistance to scaling. Therefore, any element in manufacture which adversely affects one or the other property is to be avoided, while any improvement or advance must necessarily improve the scale resisting powers without affecting robustness in service.

Chemical Specification.

Carbon.—Before white iron scales, the carbon must first burn away from the outer edges. It would seem, therefore, that the higher the carbon content the longer the life of the iron. This would be true if all the carbon remained in the combined condition as carbide, but the higher the total carbon content, the sooner the deposition of free carbon (graphite) on annealing, everything else being equal. As this free carbon is readily combustible, and burns away, leaving in its stead enlarged cavities, and later oxide, as shown by the photomicrograph of Fig. 6, there is a direct contradiction of the first premise. To consider the quantity of carbon, therefore, without a knowledge of its stability as a carbide and constitution, may be more misleading than instructive. It may be safely stated, however, that the higher the carbon, the longer the life, providing the graphitisation period is not decreased; in other words, the advantage of an increased carbon content can only be assured by suitable adjustment of the other elements present.

Silicon.—Favouring the formation of graphite and readily oxidising to silica, silicon is an undesirable element so far as longevity under the direct influence of temperature is concerned. Conferring toughness, reducing liquid shrinkage on solidification, and being the most economical natural deoxidant, only such quantities as enable solidity of casting and promote deposition of graphite at such a rate as will confer the desired toughness without accelerating oxidation, should be present.

Manganese.—Carpenter and Reegan* show that with a constant carbon of 2.4 per cent., and manganese ranging from 0.51 to 1.6, 151 heatings caused a volume increase of 7.49 per cent. in the

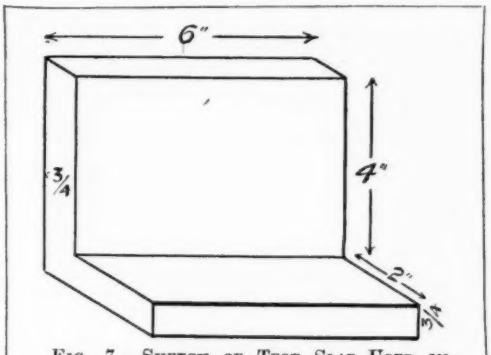

Fig. 7.—Sketch of Test Slab Used in Heat Test.

0.51 per cent. manganese bar. With 0.935 per cent. manganese, the same treatment produced an increase of 3.10 per cent., and with 1.6 per cent. manganese 151 heatings produced no change in volume.

A. Levi, discussing cast iron subjected to repeated heats and coolings at temperature not exceeding 900 deg. C., states that "In the manufacture of heat-resisting cast iron it is desirable in practice to obtain in particular:—

"A high manganese or chromium content, these elements forming stable carbides which resist annealing. These carbides are of the type (Fe Mn)$_3$ C. Their stability retards increase of volume subsequent to the first heat." Campion considers carbides of manganese are more resistant to heat than the corresponding compounds of iron. Mn, therefore, plays an important part in preventing growth and loss of strength when the iron is subjected to high or fluctuating temperature conditions. The graphitising influence of silicon is partially counteracted by manganese. Besides functioning to promote stability of the carbide, manganese is an efficient deoxidiser and cleanser, and neutralises the influence of sulphur.

Sulphur.—Sulphur exists in cast iron in three

* Carpenter and Reegan, Journal Iron and Steel Institute, 1911, No. 1.

forms—manganese sulphide, non-sulphide and organic sulphur.

The stability of the carbon as carbide, hence the resistance to scaling and growth, is a function of the quantity of sulphur that crystallises with the carbide. Because of the powerful effect of sulphur in this direction, and because of the preferential affinity of manganese for sulphur forming an inert material, it would be more desirable in scale-resisting castings than a low sulphur and high manganese. Making cast iron tender at a red heat, causing quicker solidification, and, under certain conditions, blowholes and dirty iron, its presence is undesirable. It is considered that 0.01 per cent. will neutralise fifteen times as much silicon.

Phosphorus.—Rendering iron more brittle under shock, reducing the hot-strength, accentuating the deposition of graphite, and because of its tendency to segregate, phosphorus must be under rigid control. Making metal more fluid and thin, reducing its melting point, and decreasing contraction, it has this in its favour.

Gases.—While exerting a profound influence, there is no reliable information on the quantity or the form gases take, or of their ultimate effect on the physical properties and behaviour of the iron in service. The work of Johnson, Oberhoffer, Piwowarsky, Jominy, Ekman, and Jordan on this subject is well known. It is established that irons melted under oxidising conditions have distinctive and different properties from those melted under reducing conditions, everything else being equal; but a method of estimating correctly the quantity and form of the various gases existing in cast iron still remains to be found. Although there is definite proof that iron melted with any excess of

Fig. 8.—Iron No. 4 of Heat Test. Micrograph of Central Zone.

air takes a higher chill, possesses a finer grain, is more fragile and brittle hot, has greater strength and toughness at ordinary temperatures in the absence of any mechanical defects, no evidence exists that oxygen as such is the cause.

Heat Tests.

To obtain more specific and comparative information on (1) the relative effects of the various elements; (2) the best combination of elements of white iron for high temperature work; and (3) the effect of different melting conditions, a series of test slabs were cast from cupola melted iron in green sand to the form shown by Fig. 7. Any adhering sand was removed and the iron slabs accurately ground. The slabs were then heated in an oil-fired, muffled furnace under oxidising conditions to a temperature averaging 870 to 925 deg. C. for 14 days continuously, arranging to cool each to a black heat in open air as quickly as possible every day, and then to replace immediately, in the hot furnace.

Effect of Carbon.

The chemical composition of the irons and appearance of fractures are detailed in Table IV. Under impact test slab No. 1 proved most brittle and No. 3 the best able to withstand shock. The per cent. loss by scaling and appearance of fracture after tests are set out in Table V.

These show best results as far as scaling was concerned, obtained from the 3.01 per cent. carbon iron, although No. 3 yielded the toughest iron.

Silicon.

Four castings of the composition given in Table VI were used to investigate this element.

Test IV.—*Chemical Composition Test Slabs and Appearance of Fracture.*

No.	T.C.	Si.	Mn.	P.	S.	Fracture.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
1	2.70	0.52	0.23	0.192	0.165	White
2	3.01	0.55	0.33	0.376	0.169	White
3	3.67	0.58	0.19	0.184	0.184	White

Table V.

No.	T.C.	Loss by scaling.	Fracture.
	Per cent.	Per cent.	
1	2.70	30.2	Slightly mottled.
2	3.01	28.3	More mottled than No. 1.
3	3.67	29.2	Mottled a little more than No. 2.

Under impact test, the resistance to shock increased as the silicon content although none was exceptionally brittle.

In their relative capacity to resist oxidation on heating, the test bars did not display any real

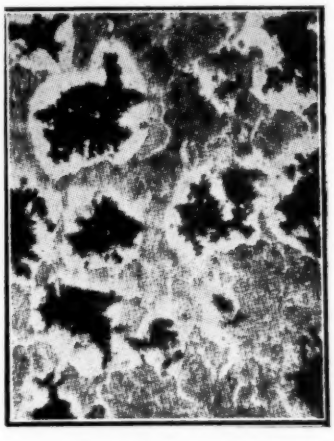

Fig. 9.—Iron No. 7 of Heat Test. Micrograph of Central Zone of Specimen. × 150.

difference. The scale was very adherent to No. 4 but easily removed from No. 7.

Table VI.—*Analyses of Castings Used in Test to Investigate Effect of Silicon.*

No.	T.C.	Si.	Mn.	P.	S.	Fracture.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
4	3.01	0.55	0.33	0.376	0.167	White
5	3.174	0.66	0.34	0.380	0.165	White
6	3.270	0.79	0.32	0.364	0.210	White
7	3.261	0.98	0.35	0.400	0.198	White

The explanation of the apparent similarity to resist scaling is found from photomicrographs of Figs. 8 and 9 representing irons Nos. 4 and 7, respectively. These photographs were taken from the central zone of each specimen. Except for the presence of a few pit holes and a slight dissociation of the carbide the structure of the 0.55 per cent. silicon iron is unchanged. The carbon content of this zone is about 2.20 per cent. The photomicrograph of Fig. 9 shows that the effect of the increased silicon content has been to cause precipitation of patches of graphite (shown as black), which are surrounded by ferrite (pure iron).

The matrix is carbide containing approximately 0.80 per cent. carbon. The total carbon content of this zone may approximate 1.60 per cent.

The deposition of graphite in this specimen followed by subsequent oxidation has caused the iron to swell, and for this reason the scaling test is somewhat misleading. It is obvious, however, that in actual service this iron will have a shorter ultimate life than the lower silicon iron.

It may be concluded that:—(1) 0.55 per cent. silicon resists oxidation better than the higher silicon irons, presuming the castings are uniformly solid; (2) where toughness, because of method of handling, is essential and where casting difficulties are encountered, the higher silicon series are preferred, but the Si-content should not exceed 0.80 per cent., and (3) the Si-content should vary in proportion to the section of the casting.

Table VII.

No.	Si.	Loss by scaling.	Fracture.
	Per cent.	Per cent.	
3	0.55	28.3	Outer edge ⅛ in. crystalline, remainder just turning mottled
4	0.66	28.1	Outer edge 3/32-in. crystalline, remainder distinctly mottled.
5	0.79	28.1	Outer edge 3/32-in. crystalline, remainder more mottled than No. 4.
6	0.98	29.0	Outer edge crystalline, remainder fine grey.

Manganese.

Thus far low manganese and high sulphur irons have been used for test purposes, and although each element is beneficial in increasing the stability of the carbide, yet they neutralise each other in this respect. It was decided therefore to employ low sulphur irons and thus eliminate the effect of the sulphur as far as possible.

Details of composition and appearance of the fracture of each iron are given in Table VIII.

A striking effect of the manganese was the refining influence on the outer zones of the metal in immediate contact with the scale. In the low manganese iron the edges are coarse and crystalline, exhibiting bright facets. As the manganese content increases this band is reduced in dimension and the texture becomes finer until at 3.00 per cent. it is almost silky. It was also observed that as the manganese content increased, the scale was less adherent.

Table VIII.—*Data of Irons Used in Test to Show Effects of Manganese Chemical Analyses and Fracture.*

No.	T.C.	Si.	Mn.	P.	S.	Fracture.
7	2.93	0.66	0.28	0.32	0.083	White
8	3.06	0.73	0.65	0.40	0.076	White
9	3.06	0.63	1.18	0.33	0.074	White
10	3.32	0.82	2.27	0.35	0.068	White
11	3.12	0.74	2.97	0.34	0.059	White

Resistance to Scaling and Appearance of Fracture After Test.

No.	Mn.	Loss by scaling.	Fracture.
	Per cent.	Per cent.	
7	0.28	28.1	Outer edge ⅛-in. crystalline, centre just turning mottled.
8	0.65	29.3	Outer edge ⅛-in. less crystalline than No. 7, centre mottled.
9	1.18	30.2	Outer edge 7/64-in. less crystalline than No. 8, centre mottled dark colour.
10	2.27	30.5	Outer edge 3/32-in. very fine texture, centre as No. 9, a little darker colour.
11	2.97	30.2	Outer edge 3/32-in. like fracture of hardened tool steel, centre black colour.

The order of toughness after the scaling treatment was:—Nos. 7, 11, 8, 10, and 9.

These results show that while manganese may be beneficial in reducing or preventing the growth of grey irons subjected to repeated heating and cooling, and that while quantities of up to 1.50 per cent. are considered advantageous in such castings as superheaters and fuel economiser headers, Diesel engine parts, lead and antimony pots, special stoker and grate parts, etc., there is no advantage to be gained from the use of manganese in either low sulphur or high sulphur white irons.

It may be concluded from the above tests that manganese:—(1) Reduces the resistance to scaling; (2) increases graphitisation, and (3) decreases strength, and that this element should not be allowed to exceed 0.30 per cent.

Phosphorus.

The compositions of irons made to investigate the effect of phosphorus are shown in Table IX. The fall in strength and increased brittleness

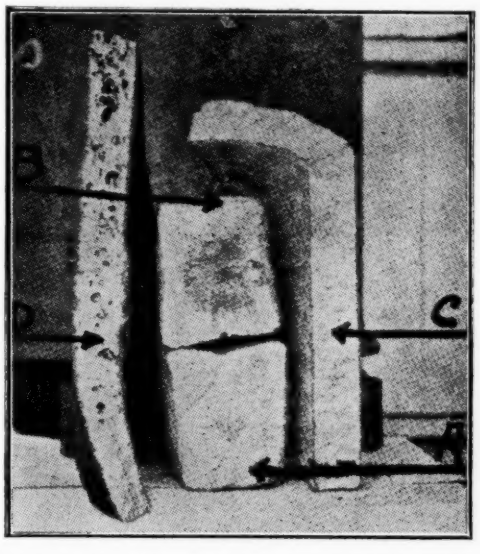

Fig. 10.—Draw Test Bars and Normal and Oxidised Metal. A and B, Draw Test Bars; C, Normal Metal; D, Oxidised Metal.

accompanying a rising phosphorus content are indicated by the transverse test results set out in Table X. Under impact tests, irons Nos. 18, 19 and 20 proved so brittle that in the presence of

Table IX.—*Chemical Analyses and Fracture of Test Iron to Show Effect of Phosphorus.*

No.	T.C.	Si.	Mn.	P.	S.	Fracture.
15	2.94	0.49	0.24	0.198	0.153	White
16	3.12	0.62	0.24	0.310	0.176	White
17	3.06	0.58	0.27	0.700	0.182	White
18	2.85	0.68	0.24	1.81	0.211	White
19	2.55	0.56	0.22	2.73	0.220	White dull
20	2.20	0.55	0.21	3.41	0.233	White dull Amorphous

Table X.—*Effect of Phosphorus.*

No.	P.	Transverse strength.	Deflection in
	Per cent.	Lbs.	In.
15	0.198	4,410	0.11
16	0.310	3,670	0.10
17	0.700	3,390	0.10
18	1.810	3,320	0.09
19	2.730	3,020	0.08
20	3.41	2,320	0.04

Table XI.—*Effect of Phosphorus on Scale Resisting Properties.*

No.	P.	Loss by scaling.
	Per cent.	Per cent.
15	0.198	28.2
17	0.700	26.3
18	1.810	27.0
19	2.73	38.0
20	3.41	63.0

such quantity of phosphorus, white iron is quite unsuited for any purpose where ordinary strength and rigidity are required.

Table XI shows that the adherence of the scale diminished as the phosphorus content increased. The toughness after the scaling treatment was similar in irons Nos. 15 and 16. Iron No. 17, while more brittle than irons Nos. 15 and 16, was sufficiently tough for ordinary service conditions. Nos. 18, 19 and 20 were brittle.

These tests show that phosphorus in normal quantities common to ordinary scrap iron is not detrimental. When present in excessive quantities it exerts a marked influence. The exact

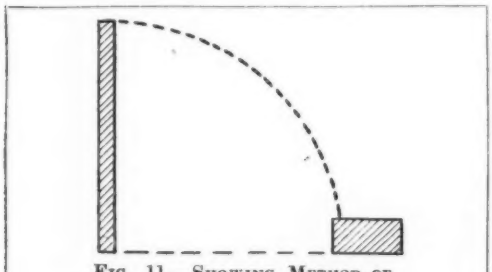

Fig. 11.—Showing Method of Testing Brittleness in Relation to Oxidation, Casting Temperature and Rate of Cooling.

nature of this influence is not clearly shown by the scaling tests, for the failure of irons Nos. 19 and 20 is not due alone to rapid oxidation but to the adverse effect of phosphorus on the strength of the iron hot. It is for this reason rather than because of excessive scaling that phosphorus must be avoided. Where the service temperature reaches 870 deg. C., 0.50 per cent. is the maximum quantity permissible for ordinary purposes; where 900 deg. C. is reached, 0.35 per cent. is a safe maximum; and where a temperature of 925 deg. C. is encountered, 0.20 per cent. should not be exceeded.

Sulphur.

Three casts were made with sulphur: 0.083 per cent., 0.167 per cent. and 0.326 per cent. Details of chemical composition and appearance of fracture as cast are given in Table XII. When correctly melted and poured suitably hot, the liquid shrinkage and general soundness of each iron were satisfactory. If oxidised or poured cold, high sulphur caused unsoundness and excessive drawing on solidification. Under impact test alloy 14 proved most brittle.

The microstructure at the central zone of the scale test slab after 14 days' continuous heating is very similar to what it was before heating. The carbon content was about 2.6 per cent.

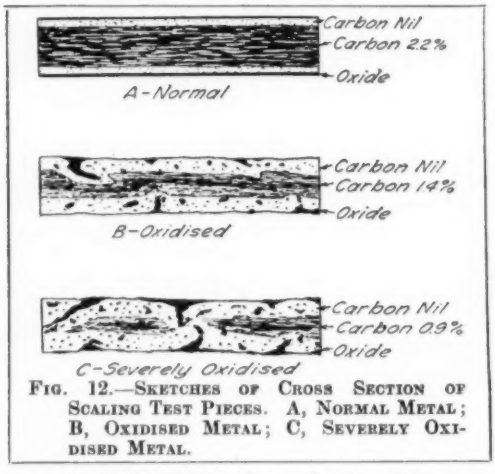

Fig. 12.—Sketches of Cross Section of Scaling Test Pieces. A, Normal Metal; B, Oxidised Metal; C, Severely Oxidised Metal.

In that high sulphur has reduced scaling some 3 per cent., it is beneficial; in that it embrittles, and that this excessive brittleness is not removed after long annealing, it is detrimental. For this reason excessively high sulphur should be guarded against, although where heavy section and severe oxidising conditions are encountered it has exceptional value. For general purposes a sulphur content of 0.20 per cent. is recommended.

Oxidised Iron.

The drops of iron in their descent over the incandescent coke of the tuyere region may be oxidised to a greater or lesser degree, determined

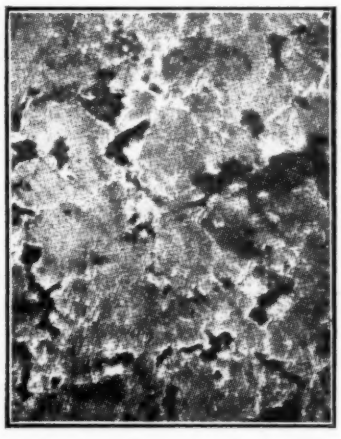

Fig. 13.—Photomicrograph of Centre Zone of Oxidised Slab.

by the nature of the irons melted, the coke to iron ratio, the blast pressure and the speed of

Table XII.—*Chemical Analyses and Fracture Appearance of Test Irons to Show Effect of Sulphur.*

No.	T.C.	Si.	Mn.	P.	S.	Fracture.
12	2.93	0.66	0.28	0.32	0.083	White
13	3.00	0.55	0.33	0.376	0.167	White
14	3.02	0.51	0.26	0.37	0.326	White

Table XIII.—*Effect of Sulphur on Scale Resisting Properties Scaling Test.*

No.	S.	Loss by scaling.	Fracture.
	Per cent.	Per cent.	
12	0.083	28.1	Mottled
13	0.167	28.0	Slightly mottled
14	0.326	25.3	White

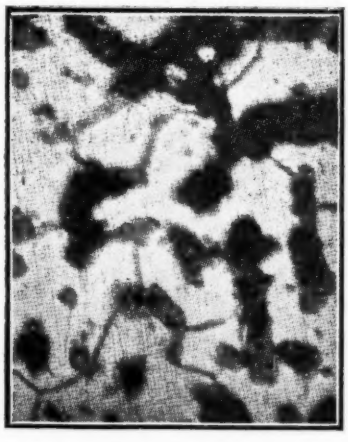

Fig. 14. — Photomicrograph of Oxidised Iron in Last Stages of Collapse after the Scaling Test.

melting, increasing the stability of the carbides under heat influences, enabling a deeper chill, while irons made under strongly oxidising conditions have these advantages. The disadvantages

are: Reducing control of chemical composition uncertain; inducing a weak crystalline structure and high liquid shrinkage, which causes excessive cracking in manufacture, increasing the susceptibility of the iron to fracture on sudden heating and cooling; and being responsible for both surface and internal mechanical defects. The above advantages are more than offset by the disadvantages.

As modern tendency is directed towards cheapening the cost of castings rather than establishing and selling to a predetermined service guarantee, average cupola practice inclines toward oxidising conditions. Oxygenation, however, despite its far-reaching and potential influences, is a factor rarely considered. It is not uncommon to hear of claims made concerning successful melting using a 1 to 10, 1 to 12 or 1 to 14 coke to iron ratio, but investigation invariably reveals that the saving in coke is more than absorbed by the increased expenditure on irons. Foundries using all-scrap mixtures have been known to offer bonuses to their superintendents on coke saving—a pernicious practice that often succeeds in increasing the number of bad castings, waste metal and ladle repairs. The most baneful effects of oxidised conditions of melting manifest themselves in both chilling and white irons.

To demonstrate practically the effect of an oxidising condition on the heat-resisting properties of white iron, a series of test slabs were made, varying the degree of oxygenation by increasing the blast pressure, using light scrap and reducing the quantity of coke. The extent of oxygenation was measured by the colour of the fumes from the cupola stack, which varied from a light grey to a deep red.

Draw Tests.

Under correct melting conditions, the liquid shrinkage of this iron on solidification approximates 1.3 per cent. When deep brown fumes are pouring from the cupola stack, it is 6.3 per cent. The marked effect of slight differences in the degree of oxygenation exhibited by the fracture of the sample draw test bar is shown in Fig. 10. These specimens represent iron melted under satisfactory conditions when the fumes of the stack were free from red colour and when reddish-brown fumes were emitted. The Brinell hardness test failed to reveal any difference between the hardness of correctly melted and oxidised irons. Brittleness increased in direct relation to oxidation, casting temperature and rate of cooling. This was measured by allowing a plate 1 in. thick and 24 in. long to fall from the vertical through an angle of 90 deg. on to the edge of a cast-iron block, as shown in Fig. 12.

Under similar conditions of casting temperature and rate of cooling metal could not be broken by the dropping test, whereas oxidised metal broke readily, sometimes on the first fall. Casting strains from uneven cooling, weak crystal structure from casting too hot and too rapid cooling, exert an equally embrittling influence on both the correctly and incorrectly melted metal.

Scaling Tests.

Sections through the test slabs on scaling show that because of the general unsoundness of those cast from oxidised metal, and because of the presence of mechanically contaminated oxide, any comparison of the relative loss of scaling is unfair, for in some places the severely oxidised slabs were almost eaten through, and wherever an oxide inclusion existed on the outer surface of the casting, this was sufficient to start a local attack which rapidly penetrated the mass. The general appearance of the normal, medium, and strongly oxidised metal after scaling tests are shown by the cross section etchings A, B and C of Fig. 12. Where the sections of the test slabs made from oxidised metal were not pitted or otherwise unsound, the loss from scaling was 3 to 4 per cent. greater than that of the ordinary melted metal. The more rapid loss of carbon from the oxidised metal is apparent from the increased thickness of the carbon-free zones in immediate contact with the scale shown by etchings B and C of Fig. 12, while the photomicrograph of Fig. 13 shows the centre zone of the oxidised slab to contain less than 0.90 per cent. carbon. The black patches in this photograph surrounded by a white border is contaminated oxide. The photomicrograph of Fig. 14 shows an oxidised iron in the last stages of collapse after the scaling test.

It may be concluded that any practice conducive to oxidation, unless corrected by subsequent treatment either in the ladle or by duplexing, creates a condition which not only impairs the general physical properties of the iron, but materially shortens its service life under heat oxidising conditions.

Foundry Query.

Casting Brass Bars in Iron Moulds (Page 302).

I believe that a perusal of the attached drawings (Fig. 1) will help "Dominion Founder" to overcome his difficulties, as the method outlined has proved very successful for the production of brass bars. Sizes above 1 in. dia. may be cored out, and machined to size:—

"Home Founder."

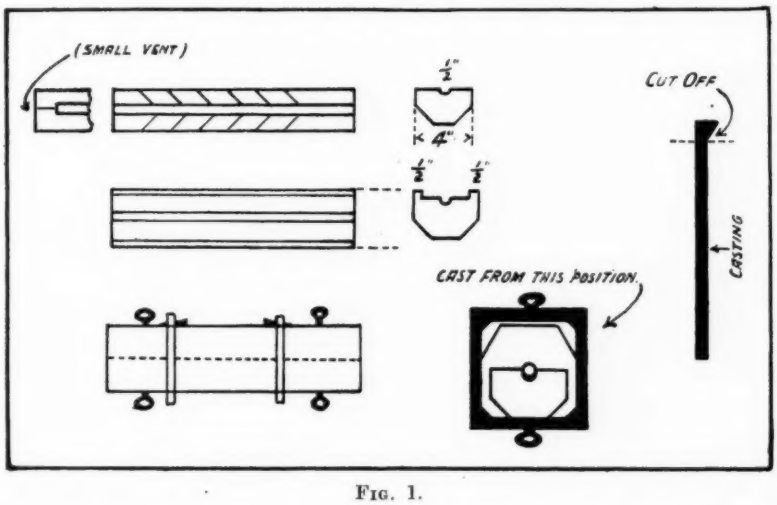

Fig. 1.

The King's Dock Works at Swansea, of Baldwins, Limited, resumed operations last week, and the mills at the Mannesmann Tube Works, Landore, on the previous Monday.

In connection with a dividend to be paid by Mr. T. Oldham, carrying on business at Albert Hill, Darlington, iron and steel merchant, the last day for receiving proofs is October 25.

Foundry Purchasing.—I.

By Eric N. Simons.

One of the greatest sources of waste in the foundry history is imperfect buying. An investigation into the methods of some of the best-known firms would almost certainly reveal a constantly recurring series of losses due to inefficient organisation, defective buying principles, or departmental jealousy. It seems to be assumed in many instances that buying is easy work, the mere placing of orders at the lowest figure quoted. In more than one firm the custom of allowing each department to do its own purchasing of supplies is still maintained. Elsewhere, there even survives the system whereby the foreman has power to order materials for use in production.

The wastefulness of these obsolete methods cannot be too strongly emphasised. Under the heading of imperfect buying organisation may come, for example, insufficient records, defective buying principles, and so forth. It is important to stress here the necessity for centralised buying in the foundry industry.

Centralised Buying.

Individual or departmental jealousy is usually the stumbling block in the way of the central buying department and its establishment. A machine shop that has been accustomed to order its own lathes and lubricants, a moulding shop accustomed to order its own sand, does not willingly relinquish the privilege. Some sort of educative policy is needed to show departmental managers that any such attitude is short-sighted. Obviously, a central buying department can obtain more favourable prices for bulk quantities, can handle deliveries with more facility, can arrange storage and transport more economically, for all the departments, than any one department can do for itself. Before going into the matter of exceptions to this rule of centralised buying, it will be as well to summarise the advantages the former offers.

(1) One official is able to devote the whole of his time to the negotiations necessary in efficient purchasing, leaving departmental managers free to attend to their own essential tasks.

(2) Uniformity of supplies is secured.

(3) Better prices can be obtained. It is obvious that if all requisitions for supplies are sent into the central office buying can be more often done in bulk; and in any event, more price reductions for quantity orders can be obtained than would otherwise be the case. Bulk orders involve not only savings in actual buying price, but also savings in carriage, cartage, and other similar charges.

(4) Money is saved through the reduction in the number of separate accounts opened with suppliers in the accountant's books. This all means less clerical work in posting ledgers, typing letters, keeping records, making out cheques, filing, and so forth; and less expense in postage, stationery, ledgers, cheques, telephone calls, and other incidentals of purchasing.

(5) There is an advantage also in the frequent interchangeability of material among departments. For example, assuming that no centralised buying office exists, it is on the cards that two different departments may have two different kinds of grinding machines. One department may run out of grinding wheels, and be delayed in the delivery of an important order because the supplier is slow in delivering a fresh supply. Yet the other department may have a plentiful stock of wheels that could be used in the emergency, but for the fact that they do not fit the other machine. Had a centralised buying department purchased these machines, it might—the writer does not assert that it would, for obvious reasons concerned with production—have purchased two alike, so that in case of need one department could have drawn upon another's wheel stocks. This is an instance chosen at random, but any manager with experience will be able to picture similar instances of a perhaps more serious character. When supplies are standardised, it happens far less often that one department is kept standing for lack of ordered goods. It can draw upon the general stocks until new supplies arrive.

(6) Buying records can be kept more accurately, systematically, and effectively. In fact, the writer is tempted to declare that only in a central department are they so kept. The individual departments are usually far too busy to spend overmuch time on details that they feel to be superfluous. Sometimes memory alone is relied upon. Yet, as will be shown later, accurate and complete buying records are indispensable to efficiency.

(7) The buyer's bargaining power is increased. He can negotiate with the knowledge that he possesses, and is known to possess, real authority to decide terms and place contracts. It is always a mistake to allow salesmen or heads of supplying firms to call direct upon departmental managers, engineers, or other influential members of the organisation. They then regard the purchasing official as a mere cipher, without power or position, and in their negotiations with him are firmer in their demands than they would be if they knew him to be the final arbiter.

Outstanding Exceptions.

There are one or two instances in which the rule of centralised buying must to some extent be broken. First and foremost among these comes the buying of highly technical goods. The buyer for a firm may be the most able man in the world, and may have highly specialised knowledge of one or even two foundry branches, but he cannot claim a complete and thorough knowledge of every industry from which he has to buy. When dealing with standardised goods whose technicalities are few and easily grasped, *e.g.*, cotton waste, typewriter ribbons, lubricating oil, and so forth, he can safely be left alone to make good bargains. But when it is a question of choosing an electrical transformer, or a steel furnace, or a smoke-preventing device, or a gantry crane, it is obvious that specialised knowledge is needed. This is the obstacle before which many centralised foundry buying systems have broken down, and it is the chief argument of those who support departmentalised buying. But it must be borne in mind that the function of the buyer is partly to relieve the departmental managers or engineers of the tedious responsibilities and routines of buying. This he can do, whether he knows one end of a transformer from another or not. He can obtain as many catalogues or booklets as the technical men need to help them in their choice. He can send out as many inquiries as may be necessary. He can keep all the records of the transaction, and conduct all the necessary correspondence. If he did nothing else, he would materially have lightened the work of the department for which the goods were required. But, in addition, he is, by virtue of his experience and knowledge, trained in the art of negotiation for purchase. He knows all the little ways of obtaining the last possible reduction from suppliers. And even though he may have no practical knowledge of the machine or material he is required to buy for a department, he can, and does, effect economies by negotiation that the departmental manager, with his inferior experience, could not.

Some further notes on this subject of centralised buying will be given in the next article.

"Life" and Fluidity.

M. Léon Guillet, in a lecture before the Academie des Sciences, continued to outline some research work done in collaboration with M. Portevin, which is of the utmost importance to founders, as it refers to a metallic product capable of filling more or less exactly any given mould. This property practical people call "life" (coulabilité). For binary alloys, corresponding to simple thermal diagrams, notably for the tin-lead and tin-bismuth, a relation exists between this property and the actual diagram. The alloy which melts at the lowest temperature is that which give the best results from the point of view of "life." The remarkable thing is that no relationship exists between "life" and fluidity. The former is a specific quality of an alloy governed by the rate of solidification.

Fifty Years of Foundry Progress.

The Lancashire Branch of the Institute of British Foundrymen began the session 1926-27 with a meeting held at the Houldsworth Hall, Deansgate, Manchester, on Saturday, October 2, when Mr. S. G. Smith delivered his presidential address, which took the form of a Paper entitled "Notes on Foundry Progress." Mr. J. Masters took the chair. In the course of his address Mr. Smith said:—

Mr. Masters and Gentlemen,—During my experience of upwards of 50 years as a foundryman many changes have taken place and much progress has been made. Twenty-five years I have spent on the foundry floor, and the remainder in more or less responsible or executive positions. As my Presidential address, I propose to make a brief survey, and touch upon some phases of work that have in recent years, or at least during my association with the foundry, made some advancement.

Foundry Conditions.

It has never been satisfactorily explained why the coming of favourable foundry conditions has been so long delayed. Not very many years ago a large number of our foundries were anything but desirable. Where windows once existed frames only remained, and in the winter some substitute took the place of the missing glass. Most of the top light came through holes in the roof, and generally there were plenty of inlets for the rain, and these inlets had also to act as ventilators. If there was any glass in the roof, it was mostly in colour like black Japan. Light and heat had not been the first consideration in our foundries.

Probably many as well as myself have had the unhappy experience of leaving an unfinished mould over-night and finding it half washed away on returning the next morning.

One of the greatest enemies in the foundry is water, and whether it comes from above or underneath, it is equally dangerous. When moisture and molten metal meet there is always a quarrel, and considering that a drop of water expanded to steam increases its volume 1,728 times, or, in other words, that a cubic inch becomes a cubic foot, it is not surprising that we sometimes have blown castings, especially when much of the material used is exposed to the elements. We have witnessed very terrible results when pouring large loam castings due to moisture penetrating the bottom of the mould during and after the assembling. These results are not intended as an indictment, but I put the question, not beg it—Are many of our foundries at the present time desirable places to work in, and do the conditions favour the production of the best kind of castings?

It may be urged that the whole matter of best conditions is in our own hands; then I ask—How long has this been so? It is only during the past 25 years that foundrymen have had the audacity to make a stand, and insist that if they are to produce the best work they must have best conditions. As a result of persistent overtures, foundries are considerably improved, and are being improved still further.

Before the "one break" system became operative, a moulder perforce of circumstances was satisfied to cook his breakfast rasher of bacon on his spade. We are glad to know now that many factories, especially modern ones, have well-equipped "mess" rooms, and will either provide, or cook, meals for their workmen. Progress in this direction is very much appreciated.

Foundry Layout and Equipment.

The layout and general arrangement of an iron-foundry capable of a large output of general castings either in loam or sand is so important that the existence of the foundry as a paying concern may depend upon layout alone. This, I think, is one of the matters in which we have not progressed to the same extent as we have in some other directions. There may be justifiable reasons why this is so. Many of our large foundries have grown "piece-meal." Some of them were originally of the "Peter Pan" type, and to facilitate increased production an arm has been added here, a leg has been added there, and perhaps extensions made in other directions, making eventually the foundry building a regular puzzle plot. Somewhere among the mix-up is the original "Peter Pan," minus or plus the wings.

In some foundries producing special kinds of castings considerable progress has been made in their layout, but it is the general foundries who cater for light or heavy castings made in loam or sand that require most consideration in this respect, in order that such layout may be economically sound.

In designing a building for a general foundry, apart from the question of structural strength, etc., some of the points to consider are dryness, light, and ventilation; the latter promotes the efficiency of the workers by keeping them healthy.

All materials required in the foundry alone should, on delivery, be straightway taken to a place that is in close proximity to where the materials are required. After being utilised for the purpose intended, everything should be on its way out. Materials such as pig-iron, scrap-iron, steel scrap, limestone, coke, bricks, blacking, coal-dust, barrel-bands, manure, etc., after being deposited in places allotted for them, should commence their journey from the cupola side of the foundry, and every further move of such material should be in the direction of the dressing ground, dressing benches and sandblast plant.

The internal plan of the foundry and the suitability of plant should be such that it would be no great inconvenience to make castings in either sand or loam up to a stated weight. "Closed-ends" and "bottle-necks" should be avoided. The dressing ground for both large and small work should adjoin the foundry, and the moulding box yard and pattern shop should be in close proximity to the moulding shops.

In an ideally laid-out foundry, all materials should be under cover as far as possible, and men engaged in foundry labour should be protected from inclement weather. Such protection would make for uniform working and efficiency all round.

Equipment.

Equipment is rather too large a subject even to touch upon at the present moment, but, speaking broadly, great progressive strides have been made on the whole, as is demonstrated in foundry exhibitions.

Status of the Foundryman.

There may be a certain amount of truth in the statement that if a person, or persons, a trade, a craft, or a community be held in low esteem, the position is invariably brought about by their own doing, *i.e.*, people are taken at their own valuation. Does this apply to foundrymen?

We admit that in the past foundrymen may have appeared unassuming, perhaps lacking in a measure ambition, self-esteem and a sense of importance, but when we admit this seemingly apparent failing—if failing it may be called—it does not make them less clever and skilled craftsmen. Refinement and polish are almost absent in the foundry, and do not directly contribute to the making of a good foundryman. I strongly resent the suggestion, made, of course, in ignorance, that foundrymen at any time have been truthfully held in low esteem, and I assert that skilled moulders are as scientific in their methods and practice as men engaged in any other mechanical calling or profession.

A rather striking statement was made last session in a valuable Paper by Major Appleyard to this effect: "That in the engineering trades there existed only three craftsmen—the blacksmith, the patternmaker and the moulder." This view should somewhat level up our ideas on status. If working foundrymen are not all technically educated, they possess some inherent quality which is a good substitute, and its name is therefore immaterial. If we pause a little and examine how we are progressing in this direction, we will note that doctors and professors of metallurgy, editors and others with whom we are personally familiar, do not think it beneath them to grub about with sand-rats in the foundry.

Moulding and Core Sands.

Important advances have been made in preparation and utilisation of foundry sands. During the past quarter of a century volumes and volumes have been written, and, apart from the determination of its composition, much research work has been accomplished by investigators and experimenters.

It is now possible to obtain direct from the quarries foundry moulding sands which comply with a stated fusion test, and I think in some instances with definite sieve tests also. This is of much value, especially to steel foundries. In my opinion, the fusion test is of more importance than analysis, providing porosity, permeability and bond are equal.

The almost general adoption of oil and silica sand cores in iron, non-ferrous and steel foundries has been an outstanding feature during recent years. The very fine, pure and clean silica sands now obtainable, some of them standing up to a fusion test of from 1,600 to 1,800 deg. C., have made it possible with a suitable binder to resist deformation and the high temperatures attained in any of our steel foundries. Let us refer back for a moment to the ordinary naturally bonded sands. Many years ago the writer gave much time and thought to the possibility of classifying or standardising by analysis moulding sands for various sections of castings. The sands were usually delivered at that time as strong, medium and weak sands.

My first proceeding was to obtain the analysis of each grade of sands in both the red and yellow varieties. Naturally, I applied first to my own firm, who used upwards of one hundred tons of new sand weekly. To my amazement and amusement, they were unable to supply the analysis or composition of their sands. They proffered at once to instruct their chemist to supply the analyses if I would submit the samples, and this I did by selecting handfuls of what I considered strong, medium and weak respectively. In the meantime, I wrote to another firm, who were also large users of new sand, and I received an immediate reply to the effect they would send on what I required, but they afterwards confessed that they did not know the composition of their sands. The firm made a request to their suppliers for the information, and they in turn were unable to supply what was wanted. As a result, this firm also obtained complete analyses of the three grades of sand, and later I obtained complete compositions from three different sources of both yellow and red sands.

The distinctions between weak, medium and strong sands are not entirely based upon silica content, but rather on clay content, and although much may be done in mixing and milling to obtain the desired quality, roughly a strong sand is most suitable for heavy or thick section castings, medium sand for medium section work, and weak sand for thin section work. "Strong" sand contains a high clay content, "medium" sand a less clay content, and "weak" sand a low clay content.

Methods of Moulding and Modern Appliances.

Progress and development in this direction during the past half-century are remarkable and surprising, and one may cite as an example the work of the "jobbing" or skilled moulder. In many cases the hard, laborious work is much reduced, or altogether cut out by the application of mechanical appliances such as electric and pneumatic rammers, jolters, presses and other means of ramming and consolidating the sand in place of the ordinary pegging rammer. Specialised tackle, patterns, pattern plates and moulding machines have in many instances revolutionised the production of many kinds of castings, not only in quantity but in finish and accuracy.

The exactitude to which many light castings must conform to enable them to be machined in jigs, the reduction in machined parts and accuracy in location of cores all contribute to make it impossible to comply satisfactorily with ordinary hand moulding from loose patterns, and these remarks apply equally to ferrous and non-ferrous foundries. Of course, the brains to accomplish this is put into the tackle, patterns, pattern-plates and machines.

Further examples of progress are found in the manufacture of castings such as hydraulic, steam, water and gas pipes. In up-to-date pipe foundries it is a very rare thing to make a standard length of straight pipe in any other way than the vertical position. Horizontally-poured castings of this type cannot be compared with vertically-poured castings so far as freedom from defects is concerned. Large, straight-flanged circular castings of irregular length are now struck up in loam vertically in place of making a pattern and horizontally moulding it in the foundry floor. Still greater developments than these have taken place in recent years. Not only has the practice changed from horizontal moulding to vertical moulding, but to some extent both methods have been displaced by centrifugal processes. This is a revolution in more senses than one.

Although centrifugal casting of metals is not quite a new art, the application of our modern methods has been evolved during the past 25 years. As is usual in new foundry processes, difficulties were encountered and overcome, and certain problems were solved. There may still be many unsolved problems in connection with this class of work, but foundrymen are not easily discouraged, as they look upon such problems as matters of course and of daily routine.

I well remember my first intimate acquaintance with centrifugal pouring. The process was then in the experimental stages. The mould was made in sand, rammed vertically in an iron box part and dried, as is usual in pipe foundries, but it was poured horizontally. The mould was transferred to and made secure in an apparatus which revolved the mould a certain number of revolutions per minute. When the desired speed was attained the molten metal was poured in at both ends from shank ladles by means of short runner spouts, which entered each end of the mould. It was at this point where the experimenter met with some difficulty. The men were unwilling to man the shanks to pour the metal into the revolving mould. The writer volunteered to take one end, the experimenter took the other end of the pipe mould and this encouraged two other men to handle the shanks. Of course, as was expected, nothing untoward happened, and the molten metal did not "fly all over the place." The revolving was continued until solidification took place, when the box-part containing the pipe was taken from the frame and stripped for examination and tests.

Roughly and very briefly such was the method adopted during the experimental stages of producing pipes centrifugally in sand-rammed moulds. The pipes were 9 in. in diameter by 9 ft. 4½ in. long. Apart from physical tests and other factors, the absence of cores (excepting the socket core), runner gates, feeder heads and the almost complete elimination of dressing are obvious advantages of the centrifugal process of pipe manufacture.

The modern centrifugal pipe-casting machine is a wonderful achievement. The mechanical arrangement of the whole plant which has resulted in its present efficiency has entailed much forethought in devising, and much skill in carrying out; and fully to appreciate this, one must witness the whole process in operation. In addition to "spun" pipes, many other kinds of castings are now produced centrifugally, including piston rings, liners, and in some cases irregularly-designed castings other than circular are made in permanent moulds. An interesting example of the pouring of rotating moulds is a railway carriage wheel cast in steel. The mould is made in sand, and, due to the fact that it is revolved when cast, it is possible to pour it with two qualities of steel, *i.e.*, a hard-wearing rim or tread, and a soft centre plate and boss in the one casting.

In addition to centrifugal castings, there are many types of castings made in stationary permanent moulds, both in ferrous and non-ferrous foundries. The manufacture of die-castings is also increasing in importance, and in these processes much progress is being made.

In connection with the dressing and cleaning of castings mention may be made of the introduc-

tion of sand and shot blast operations, and rumbling and grinding equipment for small and medium-sized castings. These methods give a much improved appearance to the work. With the larger castings the use of pneumatic chisel and cleaning by hydraulic pressure are advancing more or less rapidly.

Drying and Baking Stoves.

In many of our modern and up-to-date foundries, considerable developments have occurred in connection with core and mould drying, and such developments are most welcome.

The contrast between ancient and modern drying units is very marked. There are not many types of foundry stoves, or methods of drying with which I am not familiar. I cannot go back as far as the wood and charcoal baking stoves, although I have seen railway sleepers thrown into the stove to assist the drying. This was in cases where coke fires were built in the corners of the stoves. Some of the oldest stoves I have known were coal fired. There is nothing very remarkable about that, but when one considers that the heat was supplied directly from a coke-making oven located in front of the stove, and in some cases partly underneath, one can imagine the condition of the inside of such stoves, and also the condition of the men who handled the moulds and cores. These conditions existed in the first foundry where I was employed, and the period was the year 1870.

Probably the evolution of drying stoves so far as fuel is concerned would be as follows:—Wood, charcoal, coal, coal gas, oil and various applications of heated air and gases.

The design of the stove deserves attention as well as the fuel, and it is perhaps at this point where we have not yet reached the ideal. Personally I contend that whatever kind of fuel is used, and whatever the mode of its application, if adequate provision is not made for the escape of the moisture formed as drying proceeds, then much heat must be wasted during the drying period. I have come to the conclusion, from the point of view of economy and efficiency, that driving, or drawing the moisture to the bottom of the stove is not the best method for its escape, as a considerable amount of "stewing" must consequently occur.

In large stoves containing heavy sand or loam work, I would suggest that a current of air in continual motion should be operative during the early stages of drying, and controlled provision should be made in the walls of the stove for moisture to escape. If this arrangement were carried out I think that we should be much nearer ideal drying and baking conditions. The current of air serves a double purpose, as it assists in circulating the heat more uniformly throughout the stove, which would considerably help towards uniform drying. It will also supply free oxygen, which is necessary when drying large oil-sand cores.

Great strides have been made in the various heating, drying and baking units, whether stationary or portable, and the efficiency, economy and cleanliness are greatly improved. When we can whitewash the inside of our stove walls and switch on the electric light, who can say the foundry is not becoming enlightened? We only need compare the first picture of the soot-laden stove with the last picture of a clean stove electrically lighted to see how far we have progressed.

Methods of Melting.

As with drying plants, progress has also been made in melting plants. In the cupola improvements have been made in many directions, yet even now we look upon it as a wasteful melting element. At its best the theoretical losses are at least 50 per cent., yet in the iron foundry there is no other method of melting in use at present that can compare with it from the point of view of convenience and economy. I look upon the ordinary cupola as a melter only, and not as a refiner.

In bygone years, and even now, in many foundries the cupola was left in the hands of those who simply followed others in its management. These cupola-men, or, as they are sometimes called cupola "tenders," made no pretence to knowledge regarding melting conditions and the reactions that take place in the cupola during melting. Very often too much or too little fuel and flux were used, yet much credit is due to many of these men for the way in which for many years they prepared and managed the cupola which they admittedly knew so little about.

During recent years this state of things has altered considerably. Our foundry managers, foremen and chargemen have become much more interested and, thanks to investigators, experimenters and specialists, much has been done to enlighten and educate the foundryman generally, with the result that cupolas in many of our foundries are scientifically controlled. Of course, contention will probably always exist to some extent with regard to air pressure and volume, area and position of tuyeres and similar matters, but the basic principles of melting will remain.

Some of the cupola developments that have been effected during recent years, or at any rate during the last half-century, include spark-arresters of various types, drop-bottoms, mechanical charging apparatus, the lever tapping and botting device, the attached and unattached and also the pulsating forehearth, the application of heated blast and the side blast-cupola with reversing heat regenerators. There is also the combination of two furnaces, the ordinary cupola and the reverberatory furnace in one melting and mixing unit. Apart from progress in these directions there is a better understanding of quantity and heat values of coke, the function of flux and of oxygen in the blast. No enthusiastic general foundrymen can very well plead ignorance of the principles of combustion and melting reactions, for in this matter alone considerable progress has been made, and there is available for use an abundance of information both theoretical and practical. In some cases, due to the present unaccountable behaviour of some cupolas, adjustments have to be made to obtain the best results, as all cupolas do not behave alike, yet the principles underlying the process are now much better understood. At the same time, finality as to the ideal has not yet by any means been attained.

In the cast-malleable, the non-ferrous and the steel foundry, branches of the industry, progress in the melting units has been very marked. In some instances the coal-fired ordinary air furnace is being displaced by gas and oil-fired regenerative furnaces, and many new oil-using elements are replacing the usual coke-fired crucible and pot furnaces in the non-ferrous foundries. In steel-foundry practice, the modified converter, the electric furnace and the regenerative gas-fired furnace have become firmly established, and improvements in manipulation are almost daily occurrences.

Progress in Use of Metals. Scientific Application.

Cast iron, that most convenient commodity, has many times been threatened and challenged owing to its shortcomings and its apparent failure to satisfy various engineers. It is an enigma to many, and until a decade or two ago it was almost untouched by metallurgists in the foundry, and its true possibilities had not been investigated.

During recent years, the very much maligned properties of cast iron have lost their sting, and the popularity of this metal for many engineering purposes has been enhanced. The progress made in mixing, melting and manipulation ensures that this material as an engineering commodity is now coming into its own. Hence we have special cast irons coupled with methods of moulding and manipulation to satisfy practically all reasonable demands. Such include castings made from low-carbon irons, non-magnetic irons, acid and heat-resisting irons. Non-growth and rustless irons may yet materialise in the near future. It is a sign of the times that it is no rare thing for practical foundrymen to discuss openly the properties, analysis, structure and physical characteristics of the metal they have to shape from pig-iron into highly finished castings to meet and satisfy a multitude of requirements for various purposes. Unfortunately this state of affairs has been too long delayed.

I can well remember the first foundry lecture to which I had listened. It was in connection with

the Cleveland Institute of Engineers and foundry foremen were especially invited. The lecturer was the late Dr. Stead, and the Paper, of course, was an excellent one, crammed full of data on the properties of cast iron and its general behaviour. During the discussion several blast-furnace managers who were present gave us a slating that I shall always remember. Although there were many foundry foremen present, not one of us said a word or made any defence. My feelings about the ignoring of our position were most intense, so much so, that when the discussion closed I, at least, made a silent vow.

I wish to make it clear that no adverse criticism or imputations were made, or offered by Dr. Stead. He was far too considerate. I do not complain. All that was said during the discussion was true. The lamentable fact was apparent, *i.e.*, we were not in the position to defend ourselves.

Just five years after this incident, having the meantime left that district, I was invited by the same Institute to give a foundry Paper before their members. With some temerity the request was complied with, and I eventually delivered one bearing the title of "Principles and Precautions in the Foundry." Without any pretence to boast I may say that during the discussion of the Paper, to which Dr. Stead sent a written contribution, in place of the kicks we received in that same room five years before, we were now receiving compliments from the same people. My vow of five years previous had materialised. Many years later, I recounted these matters in a personal conversation with Dr. Stead. He evinced much pleasure, and characteristically said: "One never knows where one is sowing the seed."

Pouring Temperatures, Heat Treatment, and Alloying.

The adoption and application of various kinds of pyrometers, especially in non-ferrous foundries is now becoming very general. It is now admitted and stressed, that the effect of pouring temperatures is of great importance, inasmuch that the physical properties of many castings made from non-ferrous metals and alloys depend on pouring temperatures, and can be improved when a predetermined temperature has been attained.

Heat treatment has made wonderful strides with all cast metals, and investigators and research workers are almost daily discovering some beneficial form of heat treatment.

The application of metallography, the development of micrography and photo-micrography in relation to cast metals and other foundry materials have made a marked advance in foundry science. Metallography, apart from its great detective value, is interesting and fascinating, and a profitable study if only as a hobby, inasmuch as it discloses in picture form practically every phase of the numerous structures in cast metals and other materials. In addition to the discoveries directly due to it, its application has often been the deciding factor in solving many problems previously unsolved.

Development of X-Rays.

How far progress has been made by the application of such a modern scientific phase in the foundry as the X-rays is rather difficult to say, and its use in the foundry, is I understand very much in the experimental stage. We have read from time to time that flaws and holes have been discovered in castings by means of X-ray examination which is nothing short of astonishing. Can we hope that some time in the future we shall be able to discern what is taking place when a closed mould is being poured. If that ever comes to pass there may be some surprises in store.

Special Metal Alloys.

Special duty mixtures of metals for various castings to meet the requirements of the engineer are considerably improving. Such alloys include cast-iron alloys and steel and non-ferrous alloys. Alloying like heat treatment is a continual voyage of discovery.

Research Work.

The value of the work done by Research Associations, and by our own Institute, cannot be overestimated. It is not so very many years since it was rarely one was able to listen to, or read a description of, a practical process of founding of any kind. Now, through the existence of our Institute and the enterprise of our Trade Journal and other journals, we have a flood of illuminating foundry knowledge and literature available and distributed throughout many of our foundries and the country in general.

It is also pleasing to note that foundry conservatism is on the decline, and this fact is a real progressive step. Practically all our foundries are now open to visitors, not only to the casual visitor but also to the specialist and to all other foundrymen. Exchange of views, methods and processes is found to be profitable all round. The foundry that keeps its doors closed is very often the foundry that has much to learn and little to impart.

I cannot conclude these notes without paying tribute to our Official Organ and to its Editor The progress made in this direction will be admitted by all. Not only are our meetings reported in its pages, but the ever-courteous Editor opens its columns to all who have something to say. Hence we not only discuss our domestic foundry troubles and problems, but we also learn what other countries are doing and how they are doing it. This has been made possible to some extent through the annual interchange of Papers and the cordial relationship that exists between Foundry Associations similar to our own in various parts of the world.

Fortunately the Editor is a truly enthusiastic foundryman. What the "floor" moulder has to say is equally as important to him as the contribution of the academic man. In other words, the Journal welcomes descriptions of foundry floor processes as much as it does scientific articles. The editor's enthusiasm "to know" has frequently induced him to make visits to France, Belgium, Germany and other countries to see for himself. We wish him a happy year in his office of President of the Institute of British Foundrymen.

Catalogues Received.

Steel Barrows.—Mr. T. Vickers, of 14, New Street, Birmingham, has sent us a four-page leaflet which illustrates and describes ten varieties of steel wheel-barrows for the foundry and allied trades.

Spectrographs and Spectrometers.—For each of these subjects Messrs. Adam Hilger, Limited, of 24, Rochester Place, Camden Road, London, N.W.1., has produced a separate brochure. With the decline of Bessemer process, the branch of science is less incorporated in works practice than formerly. When, however, trouble arises in works owing to impurities, the spectroscope is an instrument not to be forgotten. The people manufacturing black heart malleable fear chromium in their raw material, and recourse to spectroscopy might not merely reassure the metallurgist, but open up sources of supply now thought to be risky owing to lack of definite knowledge. The publication of these catalogues offers a means for founders of making closer acquaintance with this interesting science.

Book Review.

Pitman's Engineering Educator. Part 2. Price 1s. 3d. net. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2.

This number takes the subjects started in Part 1 a little further. There are articles on Gas Engines and Producers, Mathematics for Engineers, Theory of Heat Engines, Reciprocating Steam Engines, Diesel Engines, Fuel, Applied Mechanics, Power Transmission by Belting, Machine Construction and Drawing, Pattern Making and Foundry Work (by J. McLachlan and C. A. Otto), Ball and Roller Bearings, Fitting and Erecting, Gearing, Pumps, Machine Tools, Works Organisation and Management, Jigs and Tools, Pioneers of Engineering, Electro-Technics for Mechanical Students and Engineering Specifications. Thus it will be abundantly clear that by studying these works the foundryman will be able to solve many of his problems without running to the engineering department.

Melting All-Steel Charges in a Cupola Furnace.*

By T. F. JENNINGS, Garfield, Utah.

Steel scrap has been incorporated in grey iron mixtures and in that form has been melted in cupola furnaces for many years. The practice is not universal, and amateurs almost invariably come to grief in early trials, but a knowledge of how it is done is fairly common among experienced foundrymen. Metal produced by melting a mixture of grey iron, pig or scrap and steel in varying proportions is known commercially as semi-steel to distinguish it from straight mixtures of grey iron, malleable iron or steel. Also the term is applied almost exclusively to cupola-melted metal.

Development of this material has been gradual over a long period of years and represents the pioneering efforts of a great number of foundrymen. It was not *discovered* by any one person in particular, although several prominent men carried their investigations further than others. Instances are on record where over 100 years ago foundrymen strengthened their mixtures by the addition of wrought iron. These instances and others dealing with the subject up to modern times have been described in many Papers and have been published in the technical Press, so there is no need at this time in presenting a review. Among the more prominent contributors on the subject are the late H. E. Diller, James A. Murphy and David McLain. The last-named gentleman probably has done more than any other man in disseminating information on this subject among foundrymen.

Early Experiments.

Little was heard of semi-steel before the early 'seventies, when several Pittsburgh foundries tried it in their mixtures for castings requiring great strength. In the early 'eighties both Robert E. Masters and the late Thomas D. West contributed articles to the "Scientific American" describing their experiences in melting entire heats of steel scrap in the cupola. They claimed complete success in the actual melting operation, the metal was fluid, and filled the moulds readily, but the castings were hard and in the form they were poured found no commercial application. In recent years the only published material on the subject of melting entire heats of steel scrap have been confined to electric-furnace operation.

For many years the writer has been accustomed to the continual use of steel scrap in cupola operation, from 10 to 15 per cent. of light and medium weight and from 20 to 25 per cent. in heavy machinery castings. A series of tests conducted over a period of many years indicate that the best results are secured from a mixture containing not over 30 per cent. steel.

Instances are on record of entire heats of steel melted in the cupola, but these heats were comparatively small. Up to the present and outside of the author's own experience he has found no record of large heats melted in this manner.

Both in the past and present vastly different opinions prevail on the proper method of charging steel in the cupola. The author's practice differs from any he has seen practised or described.

A Few Years Ago.

The writer approached a problem of reducing an accumulation of approximately 12,000 tons of a poor grade of steel scrap into a commercial grade of hard-iron castings. He had choice of three alternatives. To build an open-hearth furnace, to install a large electric furnace, or to attempt the melting of this large amount of steel in the cupolas already in existence. In addition to the 12,000 tons of steel scrap, provision had to be made for taking care of a considerable tonnage of steel scrap incident to the operation of a large plant from day to day. The open-hearth furnace and the electric furnace were ruled out on account of the heavy initial capital expenditure.

An attempt to use this immense amount of steel scrap by mixing it with the iron charges would not cut down the pile sufficiently rapidly enough, so it was decided to try the problematical process of melting complete steel heats. The attempt was made in the face of a prevailing opinion that the cupola lining, any kind of a lining would not stand up to the increased temperature considered necessary for melting steel. Resulting experience seems to indicate that the majority of failures in melting steel are due to misconception on this point.

Mistaken Ideas.

New standards had to be developed to ensure a metal throughout the duration of the heat of sufficiently high temperature to stand transportation a considerable distance and pouring over the lip of the ladle. An impression prevails in some quarters that where steel is melted in the cupola the amount of fuel has to be increased over that required for grey iron on account of the higher temperature demanded. Otherwise it is claimed the metal will become pasty, set rapidly, and skull the ladle. Also it is claimed that the steel absorbs carbon from the fuel; therefore the extra fuel is required to supply this carbon. Neither of these claims has been substantiated in an experience of several years in melting daily complete charges of steel scrap varying from 25 to 30 tons.

Early experiments with coke of 84 to 86 per cent. fixed carbon and a high ash content showed that this coke was not capable of producing the necessary high temperature, irrespective of the amount employed. Finally we secured a coke of not less than 90 per cent. fixed carbon and a low ash content. This coke produced satisfactory melting conditions and reduced the amount of slag to a gratifying extent.

There are four cupolas in the foundry, and in the early experiments the steel was melted in the small pair lined to 45 in. At that time the heats did not run over 7 tons. At present and for the past two years we have been melting heats of over 30 tons daily for 7 days a week in the larger pair lined to 54 in. The two cupolas are used on alternate days, one in blast and one under repair.

In preparing the cupola for a heat the lining is rebuilt or repaired to a straight line with silica split brick. The joints are made tight to prevent leakage of the gas. Several foundries melting steel were investigated in an attempt to discover a suitable lining. One was found in the Chicago district using a rammed ganister lining, but the heats were small and did not offer a fair comparison.

Many Lining Materials.

After trying many forms of lining, including ganister, magnesite, and a few heat-resisting cements warranted in advance to withstand high temperature and abrasion, the best results were secured from a split silica brick laid against a silica block backing.

At first there was a great deal of trouble with the slag hole. We tried chrome brick blocks, different kinds of mixtures including graphite, a proprietary cement, ganister and clay singly and in combination, but none lasted beyond the time of melting 15 to 18 tons of metal. The hole became too large. Finally we developed a tap and slag hole formed from block silica brick with a daubing of 75 per cent. silica sand, 2 per cent. cement, and 23 per cent. good fireclay.

The first linings burned out quickly in the form of foam that came through the charging door, but we found later this was due to the manner of charging. Reducing the amount of high silicon-ferro alloy did away with this trouble.

The hearth is well rammed with a good mixture of silica sand and moulding sand. This mixture is rammed hard around the edge, but not so hard in the centre. The sand is struck off flat with a fall of 1 in. to the foot from the back to the spout. Three feet of coke are placed on the wood and a mild blast is employed until the coke shows red on top. The single row of tuyeres is located 20 in. above the bottom, and after the coke is burned through there is added an amount sufficient to bring the top 30 in. above the tuyeres. Charging then is commenced.

Steel scrap and coke are brought to the door in cars and charged by hand up to a point 3 ft. below the door sill. The remainder of the material is dumped from the cars directly into the cupola by a mechanical charging device.

* From a Paper read before the Detroit Meeting of the American Foundrymen's Association.

Small Charges.

Instead of the usual 3,300-lbs. charge, it is halved and a layer of coke is placed between steel charges of 1,650 lbs. each. The cupola melted 3,300-lb. charges, but it was found that the metal from the smaller charges was more conveniently handled and carried a higher temperature.

Scrap used in the charge is made up of nearly everything in the steel line either forged, rolled or cast. Structural shapes, plates, rods, railway scrap, rails, fishplates, bolts either in the natural state or cut to convenient handling lengths. Chunks of high manganese, high- and low-carbon steel up to 150 lbs. in weight are charged intact.

TABLE I.—*Charging Data.*

No. 7.—Whiting cupola (lined to 54 in. inside diameter).
Coke on bed charge, 1,900 lbs.
Steel on charge (full charge on bed), 3,300 lbs.
Coke on charge (full charge), 341 lbs.
Steel on charge (half charges), 1,650 lbs.
Coke on charge (half charges), 171 lbs.
Melting ratio, 1 to 7.5.
Lime rock (half charge), 75 lbs.
Pressure of blast, 14 to 15 ozs.
Maximum amount of air per minute, 6,000 cu. ft.

Physical Test Data of Metal.

Bars left in flask until cold :	Brinell Hardness Best averages.	Transverse Test.	Deflection in inches.
Bar 5	600	3,300	0.08
Bar 6	600	3,428	0.08
Bars quenched in water:			
Bar 5	—	1,420	0.07
Bar 6	—	1,130	0.05

NOTE.—A great deal of experimental work was done on the use of fluxes of a high per cent. of fluorspar. A high per cent. of fluxing material was necessary because the scrap material contained a great deal of corroded material, with fine crushed ore resembling cement adhering to the scrap. This combination was very destructive to the lining, and after much experimentation the use of fluorspar was abandoned and there was adopted as a standard the use of 150 pounds of lime rock to the full charge (3,300 pounds) and with spit charges 75 pounds of lime rock. This amount of flux causes slag flow with comparatively no mineral wool expelled from the slag hole.

The cost of high-grade ferro silicon is much higher than ferro-silicon of a lower silicon content, and in that manner the expense of operation is increased beyond reason. Further, 80 per cent. ferro-silicon limits production, since it creates a slag that quickly eats out the lining of the cupola.

While trying the high ferro-silicon, the limit of the melting capacity of a 45-in. cupola was 7 tons. After seven months of trial and experiment the ferro-silicon was gradually cut down and the steel melting was transferred to the two 54-in. cupolas and the daily charge was gradually raised until it attained the present maximum of 27 tons, sufficient for present requirements.

Under former conditions an addition of from 4 to 15 per cent. grey iron pig or scrap had to be placed in the mixture at the beginning of the heat to prime it and prevent it from chilling in the tap hole. Under the conditions finally developed no soft iron whatever is used, and no trouble of any kind is experienced with the tap or slag hole or with the lining of the cupola.

Fumes from Metal.

An unexpected problem arose when the steel heats were raised to 9 tons. When tapped into the spout ladle the metal created so much smoke and fumes that it affected the cranemen, the eyes and throat of the charging floormen, and no one could work near the cupola, causing a lot of waste space.

A large hood was erected with a 30-in. stack, but it did not wholly relieve the situation. After giving it a good deal of thought, the writer dropped one piece of alumiuium weighing 4 or 5 ozs. in the spout ladle, "before tapping out," and a piece in the ladle about the middle of the tap; this caused a reaction and did away with the smoke entirely. This method is in practical use at the present time.

The Resulting Metal.

Naturally at this point the question arises what kind of metal is produced in the foregoing manner from an all-steel charge. A metal was needed to resist abrasion, to wear down uniformly without cracking or spalling. The product is low in silicon and manganese and has a Brinell hardness of 600 to 712. There is no need for a synthetic or machinable grey iron, therefore no effort was made to secure an iron of that character.

Synthetic cast iron has been made from steel charges in electric furnaces and in small experimental cupolas at various universities, but definite information seems to be lacking in the detail of operation. Results, particularly in recarburisation, have not been positive. The introduction of silicon into the charge will increase the silicon content, but at a corresponding reduction in the amount of carbon. The most satisfactory method of raising the carbon content appears to be through the addition of ferro-chrome.*

Institute of British Foundrymen.

WALES AND MONMOUTH BRANCH.

On October 9, under the chairmanship of Mr. J. P. Galletly, the Branch-President, a smoking concert was held at Cardiff to inaugurate the opening of the session. He had as guest Mr. V. C. Faulkner, the President of the Institute, and was supported by his Vice-Presidents, Messrs. Ben Hird and Williams. An enjoyable evening was spent, and a good many contributions were made by local members and their friends. Mr. J. J. McLelland, the Honorary Secretary, not only organised the affair but also contributed songs, whilst his daughter, Mrs. Rawdon, who has a very pleasing voice, was much in request. Mr. Salmon, a blind musician, delighted his audience with several 'cello solos.

MR. GALLETLY, in opening the proceedings, said how pleased he was to welcome the President of the Institute. Each year since their inception as a branch they had received encouragement by visits from the occupants of that office. In South Wales they experienced difficulty in interesting many foundrymen in the work of the Institute on account of the distances it was necessary to travel to attend a meeting.

MR. V. C. FAULKNER said he was delighted to be amongst them, especially as the Welsh Branch was an offshoot from London. Its founder, Mr. J. J. McLelland, was previously a member of the London Branch, and there would always be a close bond between the two. Mr. Galletly had struck the keynote of the weakness in the organisation of the Institute when he pointed out the real difficulty which isolated foundries experienced in being unable to attend meetings. Every year it became more obvious that the Institute as a national—if not an international body—must give more attention to the requirements of the isolated foundry. They had, as a national body, already done certain things which no local society could accomplish. They had, for instance, made possible the organisation of the British Cast Iron Research Association, the destiny, scope and work of which was, after all, in the hands of the industry itself. Again as a national body, they had originated a specification for cast iron, which ultimately may be imposed on every foundry making grey-iron castings. If foundrymen object, when the final imposition of tests is *un fait accompli*, they can rightly be met by the answer that they had been given in the past every opportunity to take part in their framing by joining the Institute, and it was up to the foundrymen of Wales, as business men, to participate in the activities of the Institute.

MR. J. J. MCLELLAND, the Honorary Secretary, said that whilst the Branch was still a small one, his Council was satisfied that not only was good work being accomplished but it was being recognised generally. It was now an open secret that their past-President, Mr. L. P. Gould, had been approached with a view of becoming a Vice-President of the Institute. This unfortunately Mr. Gould could not see his way clear to accepting, a phase which all hoped was but a temporary one. Again, the Lancashire Branch had asked one of their members, Mr. Ben Hird, to lecture to them during the present session. He quite appreciated the President's request for the economical conduct of the Branch, and assured him that it would in every way be respected. Finally he thanked Mr. Galletly for his generosity in providing refreshments for everybody, Mr. Faulkner for giving up his week-end, and the artists. This was seconded by Mr. Hird.

[* This statement requires amplification before universal acceptation.—EDITOR, "F.T.J."]

The Condition and Influence of Sulphur in Cast Iron.

By J. E. Hurst.

(*Continued from page* 326.)

Unbalanced Conditions.

It is now necessary to consider what happens to the sulphur when the amount of manganese is insufficient to convert the S to MnS. In the case of the entire absence of Mn we know, of course, that the sulphur exists as the iron sulphide which is at least partially soluble in the iron, and according to the amount present may be expected to be either completely dissolved or exist as a ternary eutectic. This ternary eutectic may be expected to be either partially or completely decomposed according to the amount of silicon present, in which case very probably particles of iron sulphide would be visible under the microscope either associated with the carbide or in positions previously occupied by the ternary eutectic as the binary eutectic of iron and iron sulphide. In the presence of quantities of manganese partially sufficient to satisfy the requirements of MnS we have no quantitative information as to the exact course taken by the reactions. From what has already been said, it might be expected that a portion of the manganese would still be occupied by some other constituent, leaving only a proportion available for the formation of MnS. On the other hand, with low concentrations of Mn, the whole of it may be converted to MnS, leaving the excess sulphur as FeS; or, further, with very low concentrations MnS might not form at all. It is reasonably certain, although awaiting conclusive experimental proof, that with normal percentages of manganese, although insufficient to satisfy the requirements of MnS, that both sulphides, FeS and MnS are present, and the final question which remains to be settled is whether they exist separately or whether they are mutually dissolved in the manner suggested by Rohl. This can only be settled experimentally, but there are quite a number of facts which have been observed which require to be taken into consideration. These facts are largely connected with the colour of the various sulphides when examined under the microscope. MnS, as Arnold first showed, generally has a dove grey colour. It has been noted that the sulphide in steels varies from an extremely pale colour to a very dark one. Sulphides of iron are stated to be of a pale yellow to yellowish brown colour. Many investigators state that the colour of manganese sulphide is likely to vary through many tints, and Hatfield has recorded the existence of ferrous sulphide in which the sulphide was embedded in the cementite and " was of a distinctly different type, quite dove-coloured, although continuous parts of the carbide crystals." Levy in quoting Dr. Stead has remarked that as the proportion of manganese to sulphur in cast irons becomes less, the sulphide constituent—apart from its colour—behaves more like iron sulphide. In such cases this sulphide has a compound structure suggesting the possibility of double sulphides. It is remarked that such sulphides are generally observed in the form of a crystal of the familiar dove-grey colour embedded in a globular mass of the yellow-brown coloured sulphide.

In attempting to interpret these and similar observations, the suggestion of the existence of double compounds or possibly solutions of the different sulphides is difficult to resist. In so far as cast iron is concerned, the possibility of the confusion of such inclusions with slag bodies, particularly in crucible melted samples, has not been sufficiently explored. It is also necessary, if such solutions do exist, to examine their solubility, and it would appear that the solubility of FeS in iron at a temperature above 980 deg. C. should form the basis of a method for distinguishing between the two sulphides.

State of Present Knowledge.

We are now in a position to give a concise summary of our present knowledge of the manner in which sulphur exists in cast iron. In the presence of sufficient manganese the sulphur exists as the manganese sulphide MnS, which may be very slightly soluble in liquid cast iron, but is very probably completely in soluble in both α and γ iron.

In the absence of manganese the sulphur exists as the sulphide of iron FeS, which is slightly soluble in both α and γ iron. The influence of carbon on its solubility is not known, but it is probably soluble up to approximately 0.25 per cent. S in both α and γ iron. Any excess of sulphur up to 0.8 to 0.9 per cent. in the form of iron sulphide, in the presence of sufficient silicon, will probably exist as a binary eutectic of iron and iron-sulphide. In the presence of insufficient manganese to satisfy the requirements of manganese sulphide both sulphide of iron and manganese are present. The evidence is insufficient to say whether the sulphides exist together in solution and whether they are wholly or partially soluble in liquid iron, the austenite solid solution or the carbide.

The Influence of Sulphur on the Properties of Cast Iron.

The following statement, which is taken verbatim from a British text-book on iron-founding, published in 1912, is undoubtedly identical with the view held by a large number of foundrymen to-day: " With an insufficiency of manganese to satisfy the whole of the sulphur, the excess of the latter combines with the iron, so that both manganese and iron sulphides may be present. Of the sulphides, iron sulphide is the more objectionable, as it is readily fusible, and decomposes at high temperatures, gaseous sulphur compounds being given off, which, as they escape, give rise to blowholes, and therefore cause spongy, unsound and weak metal. Further, being readily fusible, it is probably the last constituent to solidify, and as a result it tends to be unevenly distributed and segregates in the middle and upper parts of the casting. Manganese sulphide is not so readily fusible, and the temperature of decomposition is higher." This statement as a whole represents the belief of many foundrymen at the present date, and lest there should be any mistake, we may state at once without any equivocation that it is, as a whole, grossly wrong.

A more rational summary of the influence of sulphur is given by Rhead about 1908, who states that this element is only too often made responsible by the foundryman for all the faults of the metal and the defects of castings. The general effects observed are that the iron is made harder, more rigid and perhaps brittle, is liable to cast more unsoundly—especially in green-sand moulds—is more sluggish, contracts more, and is thus liable to produce drawn and distorted castings with initial stresses of unknown value. The combined carbon is under ordinary conditions increased and the free carbon diminished by the presence of sulphur, and it is even probable that the total carbon in iron is diminished by the addition of sulphur. Such is the general summary of Rhead's statements, and whilst refraining from any consideration of the condition of the sulphur, or quantitative data of the limits of sulphur, below or above which the effects are observed, he states that he has on several occasions caused the element sulphur to serve a useful purpose by using it to harden and stiffen otherwise soft metal. To the broad general statement, very little exception can be taken, and the deliberate utilisation of sulphur to obtain useful physical properties is an aspect of the influence of sulphur which will be more readily appreciated to-day. Incidentally, Rhead considered 0.2 per cent. sulphur to be the extreme limit of sulphur which should be present in foundry iron, whilst for good results the amount should not exceed 0.10 per cent. It should also be remarked that the influence of sulphur in making cast iron more sluggish and liable to cast more unsoundly has been remarked upon by other observers (*e.g.*, as

recently as 1923 by Rowe, J.I.B.F., 1923/4, page 345).

All the earlier observations agree that under certain conditions the presence of sulphur tends to maintain the carbon in the combined condition, and an increase in the amount of sulphur tends to increase the amount of combined carbon maintained. Later investigations confirm the fact that this influence of the sulphur persists only in the absence of excess manganese over the requirements of manganese sulphide, which fact leads to the conclusion that the existence of sulphur in the form of iron-sulphide is responsible for its influence on the condition of the carbon. Many experiments can be quoted in support of this, and our purpose will be sufficiently served by quoting a single case given by Dr. Stead. In this case an iron containing 2.98 T.C., 1.89 Si, 0.29 Mn, and 0.27 per cent. S, a perfectly white iron was rendered perfectly grey by the addition of sufficient manganese to give 1.0 per cent. (*i.e.*, in excess of the requirements of MnS).

The exact mechanism by which the presence of FeS prevents the formation of graphite has been the subject of much speculation, but does not appear to have yet been completely elucidated. It is undoubtedly connected with the solubility of the iron-sulphide, and its presence in the austenite solid solution must exert some stabilising influence on the carbide existing in solution.

From our knowledge of the influence of silicon, it would be expected that this would counteract the tendency of the sulphide to prevent graphitisation, and as a matter of fact this is the case, and the influence of the sulphur in the iron sulphide condition is largely influenced by the silicon content. It has been endeavoured to attach a quantitative value to the relative influence of sulphur and silicon, and the older text-books generally state that 1 part of sulphur is equivalent to or will neutralise 10 to 20 parts of silicon. The evidence on which such statements are made is not clear, and as a broad statement they may be regarded as incorrect, and can only be regarded as correct within some well-defined and narrow limits. It is better to adopt the method of expression of Wüst, who states that in irons containing 3.15 per cent. total carbon and approximately 1 per cent. silicon, approximately 0.1 per cent. sulphur prevents the separation of 0.2 per cent. graphite, but with 2 per cent. silicon the effect is much less. Piwowarsky states that the effect of sulphur is also greater when the total carbon content becomes lower.

We thus have two factors in the chemical composition which prevent or counteract the influence of sulphur in preventing graphitisation. These factors are the manganese and silicon contents, and their influence is exerted in different methods in both cases. In the case of manganese the influence is exerted through the formation of the insoluble manganese sulphide, thus removing the sulphur from active participation in the graphite-forming actions. The silicon acts by exerting its preponderating influence in tending to form graphite.

The Influence of Sulphur on the Physical Properties.

The observations that sulphur tends to increase the sluggishness, the tendency to produce drawn and distorted castings and unsoundness are very probably to be ascribed to the iron sulphide condition, and due to the tendency to prevent the formation of graphite. That these observations are correct cannot be disputed, but it will be appreciated that in the presence of sufficient manganese or silicon their occurrence can be prevented.

Segregation of Sulphides and Unsoundness.

The question of the influence of sulphur on unsoundness is very difficult to discuss. There is undoubtedly a strong belief extant that the presence of sulphur in excessive amounts does tend to unsoundness and from an evidential point of view this belief is difficult to dispose of. Experimental results, however, can be given to show that under proper conditions sulphur at least does not affect the strength properties and it is legitimate to interpret such results as indicating freedom from unsoundness.

The argument that the sulphides are capable of decomposing at high temperatures yielding sulphur gases which are responsible for the unsoundness must be dismissed as untenable. The comparative ease with which cast iron will absorb sulphur and the immense difficulty invariably encountered in removing sulphur once it is absorbed should be sufficient testimony to the stability of the sulphur compounds in iron. The smell of sulphur dioxide which accompanies high sulphur irons can be accounted for by the oxidation of the sulphides at the exposed surfaces of the molten metal, and it is unnecessary to assume, nor is it likely to be the case, that sulphur dioxide arises from the actual decomposition or oxidation of the sulphur within the mass of the iron.

When the sulphur is present as the sulphide of iron its effect upon the carbon will be accompanied by increased shrinkage and tendency to unsoundness. This, however, can be prevented if proper precautions are taken even without alteration or adjustment of the chemical composition.

The Influence of Sulphur on the Mechanical Properties.

Schumaser * states that the transverse strength decreases with increasing sulphur contents, the deflection undergoes a moderate increase and the hardness increases slightly. Hamasumi has investigated a series of irons with varying sulphur contents and some of his results are abstracted in Table II. With an increase in sulphur of from 0.018 to 0.144 per cent. no harmful results are found and if anything the results indicate a slight improvement in the tensile strength values. An increase in the hardness values is also recorded. It is difficult to find general agreement amongst the results of many investigations on the influence of sulphur on the mechanical properties. This is probably due to the variation in the many conditions which may influence the action of the sulphur. This fact in itself goes to demonstrate the comparative ease with which the sulphur can be rendered harmless.

TABLE II.

Test No.	Analyses. Gr. %	C.C. %	Tot. C. %	Si. %	S. %	Mechanical tests. Max. stress. Tons per sq. in.	Brinell	Machining.
1	2.14	0.80	2.94	1.76	0.018	17.1	187	Very soft
2	1.89	0.84	2.73	1.67	0.024	17.6	187	,,
3	2.06	0.84	2.90	1.90	0.042	19.2	192	,,
4	1.98	0.77	2.75	1.84	0.067	20.3	206	Soft
5	2.03	0.72	2.75	1.80	0.086	20.7	204	Good
6	2.13	1.05	3.18	1.71	0.125	19.8	209	,,
7	1.93	0.87	2.80	1.71	0.144	20.3	223	,,

Concluding Remarks.

In attempting to summarise the results of this review of the state of our knowledge of the condition and influence of sulphur in cast iron there are quite a number of aspects of the subject revealed, upon which further investigation is required to complete our knowledge. Even from our existing knowledge the outstanding conclusion that in the presence of sufficient manganese the whole of the sulphur in cast iron is converted to the insoluble manganese sulphide can be very strongly confirmed. From a practical point of view this means that the sulphur, with the usual quantities of manganese available in many pig-irons, can be rendered quite harmless even in quantities considerably in excess of what are regarded as normal figures. It might be urged that this has been well known for a long time, and whilst this must be admitted there is still a lingering doubt in the minds of many foundrymen of the dangerous nature of this element, and any attempt to market irons of a higher sulphur content than normal, even in the presence of a sufficient excess of manganese, would not be received with great enthusiasm.

In the presence of sufficient manganese and with the additional help which can be obtained from the silicon content the sulphur can undoubtedly be rendered quite harmless, and provided careful control is exercised high sulphur irons need cause no trouble in everyday foundry practice.

* "Giesserei Zeitung," 1920, page 355.

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Trade Talk.

Short Brothers, Limited, of Sunderland, have received an order for an oil tanker for the Hindustan Steam Shipping Company. The vessel will have a carrying capacity of 10,000 tons.

The Ritchie-Atlas Engineering Company, Atlas works, Temple, Glasgow, have secured a contract for the construction of all the conveying and screening plant at a new ore mine in Spain.

An order has been received by Henry Robb, Limited, Leith, from the War Department to build a twin-screw vessel for special service. Two sets of triple-expansion engines will be fitted capable of driving the vessel at a speed of 9½ knots.

The Peterhead Corporation Gas Department has placed an order with the Woodall-Duckham Vertical Retort and Oven Construction Company (1920), Limited, for a T.I.C. tar treatment plant of a capacity of 10 tons per 24 hours.

Dorman, Long & Company, Limited, Carlton Iron Works, 214/215, Capel House, 62, New Broad Street, London, E.C.2, announce that the London office for ferro-manganese and spiegeleisen will in future be at 305, Winchester House, Old Broad Street, E.C.2.

Walker, Crosweller & Company, 54-58, Queen Elizabeth Street, London, S.E.1, have been appointed sole British representatives of Lewis M. Ellison, of Chicago, U.S.A., manufacturer of the Ellison inclined draft gauges used on boiler and other power plants.

With reference to the announcement regarding the closing of the shipyard of Smith's Dock Company, this is only a temporary measure due to the situation created by the continuance of the mining dispute, and refers to the shipbuilding department only. Work in the ship repairing department is being carried on as usual.

Mr. W. A. Riddell, president of the Frederick Iron & Steel Company, has been appointed receiver of the Hadfield-Penfield Steel Company, Bucyrus, O., U.S.A. The United States Government has mortgages of about £320,000 on the plants of the company representing money advanced during the war for munition plants.

To fill the vacancy caused by the death of Sir Charles Ruthen, the council of the Institution of Structural Engineers has elected as president Mr. Henry James Deane, consulting engineer, of Victoria Street, S.W. Mr. Ewart S. Andrews, consulting engineer, a partner in the firm of Andrews & Beaumont, consulting engineers, High Holborn, has been elected a vice-president of the institution in succession to Mr. Deane.

In spite of the difficulties of obtaining fuel, the Imperial Steel Works of Edgar Allen & Company, Limited, Sheffield, continued to maintain operations in all departments during September. The engineering department is at work on cement plant contracts. The steel department has in hand an interesting high-speed steel contract for a foreign railway, and a quantity of alloy steels for automobiles. The saw department has in hand orders for friction discs for export, and a good inquiry for battery shoes and dies has been received by the forging press department. Work in other departments is normal.

American copper producers have combined, with Government approval, for co-operative action in establishing the price of domestic copper in foreign markets. A new company, the Copper Exporters, Incorporated, has been formed, including all the leading producers in the United States, representing an enormous aggregate capital. Mr. C. F. Kelly, the president of the Anaconda Copper Company, is at the head of the new organisation. An effort will be made to sell direct to consumers except where conditions make it desirable to sell to distributors. Foreign associate members of the combine include the British Metals Corporation, the Rio Tinto Company, the South American Products Company, and leading German, French and Belgian interests.

Many buyers from all parts of the country attended the sale at Crymlyn Burrows, Swansea, by Leeder & Son, of the plant and machinery of Topham, Jones, Railton & Company. The more important lots included: Five-ton travelling crane, £500; ditto, £180; ditto, £155; ditto, £160; five-ton ditto, £160; ten-ton ditto, £150; five-ton ditto, £80; 25-ton ditto, £310; ten-ton ditto, £265; two five-ton ditto, £500 and £505; five-ton ditto, £150; twelve-ton ditto, £200; fifteen-ton ditto, £550; three five-ton ditto, £160, £180 and £155 each. Twelve-ton steam excavators, £210; ditto, £140; ditto, £160 and £110. Steam piling outfit, £170; two air compressors, £250 each; pneumatic drill sharpener, £110; portable air compressor set, £200; two twenty-h.p. petrol locomotives, £190 and £240 each; 150-h.p. haulage gear, £170; eleven locomotives were sold at prices up to £290 each; twelve-ton steam excavators at £210, £140, £160, £150 and £110; five-ton ditto, £150; 150-h.p. electric haulage gear, £140; concrete mixers at £110, £108 and £105 each.

Gazette.

Mr. J. D. Richardson, Horbury Road, Ossett, and carrying on business as a brass and iron founder at Healey Road, Ossett, underwent his public examination in bankruptcy at Dewsbury on October 7. His deficiency was £1,902, and he attributed failure to losses on making castings, heavy interest on loans, and bad trade. Debtor admitted that the petitioning creditor was a money-lender to whom he had repaid £298, and who still wanted £200. The examination was closed.

Personal.

Mr. G. H. Fairhurst, representing the Indian Iron & Steel Company, Limited, and Mr. H. FitzPatrick have vacated their seats on the board of the Bengal Iron Company, Limited, and have been succeeded by Mr. C. B. Chartres and Mr. L. Chandler respectively.

Mr. F. Treherne Thomas, chairman of Richard Thomas & Company, Limited, has resigned his seat on the board in consequence of his having removed his residence to the South of France. Mr. Henry Coulson Bond, at present deputy-chairman, has been elected chairman, and Mr. William John Firth deputy-chairman. Mr. Cedric Treherne Thomas has been elected a director, while Mr. Francis Hole, at present one of the joint secretaries, has been appointed secretary in place of Mr. David Jones, who retired from the company's service on September 30 last.

Wills.

Harrison, B. G., of Granger Harrison & Company, Limited £49,057

Vaughan, T., lock manufacturer, of Willenhall, late of H. & T. Vaughan £65,210

Jones, P. E., of Kenilworth, Kingston Road, Sketty, part proprietor of the Cwm Brook Foundry, Swansea £3,239

Smith, J., a director and general manager of the Woolston and Southampton Works of John I. Thornycroft & Company, Limited £16,833

Laverick, S. D., of North Shields, manager of the iron department at the Walker Works of Sir W. G. Armstrong, Whitworth & Company, Limited £10,370

Stephens, D., vice-chairman of the Blyth Shipbuilding & Dry Docks Company, Limited, and a director of the Port Talbot Graving Dock & Shipbuilding Company, Limited £17,128

Obituary.

Mr. M. Possart, of Cardiff, manager of Messrs. Elliott's Wire-rope Works, Collingdon Road, West Dock, Cardiff, died last week. Sixty-six years of age, Mr. Possart entered Messrs. Elliott's service as a boy and became manager when only 26.

Mr. Oliver M. Row, whose death we briefly announced in our issue of October 7, was chairman of directors of Royles, Limited, Irlam, near Manchester, and invented the well-known indented tube for feed-water heaters, etc. The deceased gentleman was 66 years of age, and after serving his apprenticeship with a firm of marine and mining engineers at Perran, Cornwall, he joined a concern in Liverpool, subsequently starting a business in Hanover Street for the manufacture of condensers and other heating and marine engineering appliances. During this period he invented the Row tube, in which the late Mr. J. J. Royle, who founded the firm of Royles, Limited, became interested. Afterwards Mr. Row gave up his own business and joined the staff of Mr. Royle as consulting engineer. The business was turned into a limited liability concern under the title of Royles, Limited, and an area of five acres acquired at Irlam, on which the present works was erected. The three joint managing directors were Mr. J. J. Royle, Mr. O. M. Row, and Mr. H. C. D. Scott. On the death of Mr. Royle in 1919, his two sons, Mr. G. E. Royle and Mr. A. G. Royle, joined the board, and Mr. Row became chairman, a position he continued to occupy until his death. He was a member of the Institution of Mechanical Engineers, a past-president of the Institution of Heating and Ventilating Engineers, and a member of the American Society of Heating and Ventilating Engineers.

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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—Conditions in the Cleveland iron market continue unsatisfactory in the extreme, business having come to almost a complete standstill, with very faint hopes of recovery to be observed in the immediate future. The position as regards stocks in the Tees-side district is absolutely unprecedented, for practically nowhere is there a ton of pig-iron of any kind to be seen. In the circumstances thus outlined it is quite obvious that prices continue in the direction of prohibitive figures, as reflected in quotations now ruling as follow:—No. 1, 125s.; No. 3 G.M.B., 120s.; No. 4 foundry, 119s.; and No. 4 forge, 118s. 6d. per ton.

As is the case with regard to foundry quality, it is now practically impossible to get a quotation for East Coast mixed numbers, and the price is nominal at about 87s. 6d. per ton. On the North-West Coast prices continue firm, with Bessemer mixed numbers £4 4s. per ton, c.i.f. Welsh ports, £4 8s. 6d. per ton delivered at Glasgow, £4 15s. per ton delivered at Sheffield, and £5 7s. 6d. to £5 15s. per ton delivered at Birmingham.

LANCASHIRE.—In this area also very little prompt foundry iron is now available, the only instances that have actually been reported being offers of Scottish No. 4 at 117s. 6d. per ton, delivered, and a certain quantity of Dutch foundry iron at 100s. to 105s., also delivered.

THE MIDLANDS.—Some small parcels of Cleveland were reported on offer at the quarterly meeting last week for delivery at the end of the month and early November, but there is very little doing in this area, as the price is out of the reach of most foundries. The current quotation is in the region of £6 15s. per ton delivered Midlands. No. 3 Scotch iron can still be obtained in one or two directions, and the price delivered locally is £6.

SCOTLAND.—Clyde-side and other consuming districts are now practically swept bare of No. 3 quality of Scotch iron, and the quantity of No. 1 available is very small indeed. Recently prices have risen daily, until the figure now named for No. 3 Scotch is 105s. per ton at the furnaces. Founders have no option now but to use Continental material, and the price for that material is also rising daily.

Finished Iron.

No improvement can as yet be reported in any of the manufacturing departments of the industry, with the major bulk of the mills and forges at a standstill, while consumers having urgent immediate requirements to meet are compelled to rely upon imported materials for their needs. Continental producers are naturally taking advantage of the position to increase quotations, and prices are consequently advancing for all classes of foreign material.

Steel.

In the Sheffield steel market the position shows little variation. There is no demand for basic billets, but a few acid billet transactions on a very small scale have taken place. Foreign steel is advancing in price, but very little is being bought here. Most of the local works have heavy order books, and the diversion of business to other countries has, so far, been comparatively small. There is no great change in the condition of the tinplate market, which has been quiet for some little time. Buyers generally are inclined to limit their purchases in view of the possibility of the coal strike being settled or ended at an early date.

Metals.

Copper.—Influenced, doubtless, by reported formation of an American Export Association, values of standard copper during the past week have continued steadily to advance, markets closing strong at nearly £2 above last week's level. A further contributory factor is that stocks of rough copper in this country are gradually decreasing, following the steady shipments to Italy and America. The amount of refined copper in official warehouses is not excessive, but, with fair quantities arriving, supplies are ample for the present restricted demand.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £59 7s. 6d. to £59 10s.; Friday, £59 7s. 6d. to £59 10s.; Monday, £58 17s. 6d. to £59; Tuesday, £58 15s. to £58 17s. 6d.; Wednesday, £58 5s. to £58 7s. 6d.

Three Months: Thursday, £60 5s. to £60 7s. 6d.; Friday, £60 5s. to £60 7s. 6d.; Monday, £59 12s. 6d. to £59 15s.; Tuesday, £59 12s. 6d. to £59 15s.; Wednesday, £59 2s. 6d. to £59 5s.

Tin.—Following an earlier slightly reactionary movement, values of standard tin at the week-end developed a further upward tendency, closing with a gain of nearly £6 on the week. America is at the moment apparently less disposed to make further provision against her near requirements, which, however, are said to be none too well covered. It is estimated that the Straits shipments may show a decrease against September of about 1,000 tons, and shipments from Batavia for October may also turn out lighter.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £318 15s. to £319; Friday, £321 to £321 5s.; Monday, £315 to £315 10s.; Tuesday, £314 10s. to £314 15s.; Wednesday, £311 5s. to £311 10s.

Three Months: Thursday, £306 5s. to £306 10s; Friday, £306 5s. to £306 10s.; Monday, £303 5s. to £303 10s.; Tuesday, £305 12s. 6d. to £305 17s. 6d.; Wednesday, £302 10s. to £302 15s.

Spelter.—The market for this metal continues fairly steady, with quotations, if anything, a shade stronger. According to a trade circular, very quiet conditions have prevailed, with less demand apparent on the part of consumers, buyers generally displaying a rather apathetic attitude.

The following are the week's prices:—

Ordinary: Thursday, £34 10s.; Friday, £34 12s. 6d.; Monday, £34 8s. 9d.; Tuesday, £34 8s. 9d.; Wednesday, £34 5s.

Lead.—Although subject to occasional fluctuations, the tendency of soft foreign pig is fairly favourable to future improvement, and the trend of values may be indicated as having taken a turn in an upward direction.

The week's prices are appended:—

Soft foreign (prompt): Thursday, £31 5s.; Friday, £31 16s. 3d.; Monday, £31 5s.; Tuesday, £30 18s. 9d.; Wednesday, £30 12s. 6d.

Institute of British Foundrymen.

WEST RIDING OF YORKSHIRE BRANCH.

The opening meeting of the session was held at Bradford on October 9, when Mr. W. Parker delivered his presidential address. The retiring President, Mr. H. Summersgill, occupied the chair.

After thanking the members for his election, Mr. Parker reviewed the progress the Branch had made, and laid stress on the individual responsibility of members. He then showed clearly the benefits derived from the national aspect of the Institute and how its work had changed for the better the conditions existing in British foundries. In reviewing the syllabus, Mr. Parker made a plea for metallurgical papers, and by amplifying Mr. Lambert's definition, drew the conclusion that metallurgy was systematised knowledge of metals, which was obviously an essential part of the education of the foundryman. Mr. Parker rightly differentiated between the ordinary foundry chemist, only capable of making analyses, and the true metallurgist, and that it was to the latter that the industry looked for a maximum amount of help. Dealing with the apprenticeship question, the President expressed the view that the boy who acquired a proper training in the fundamental principles had greater chances of advancement than those applying themselves to allied crafts. After outlining the propaganda which has been organised locally, Mr. Parker finished by expressing his personal thanks to the Honorary Secretary, Mr. S. W. Wise, for the sterling work he had put in for the benefit of the Branch.

A vote of thanks was accorded to the President on the proposition of Mr. W. G. Thornton, seconded by Mr. F. Rowntree.

The remainder of the evening was devoted to the presentation of a cinematograph film kindly lent by Messrs. Hadfields, Limited, of Sheffield, which incorporated a visit to the Hecla Works by H.R.H. the Prince of Wales.

From Foundry to College of Engineering.

Engineering students met for the first time this session in the reconstructed departmental buildings at Marischall College, Aberdeen. The University Court some time ago purchased the buildings generally known as Blaikie's Foundry, adjacent to the College, and these have now been thoroughly overhauled and reconstructed to plans prepared by Professor Blackadder, D.Sc., A.M.Inst.C.E., of the Chair of Engineering in the University, under whose supervision the whole work was carried out.

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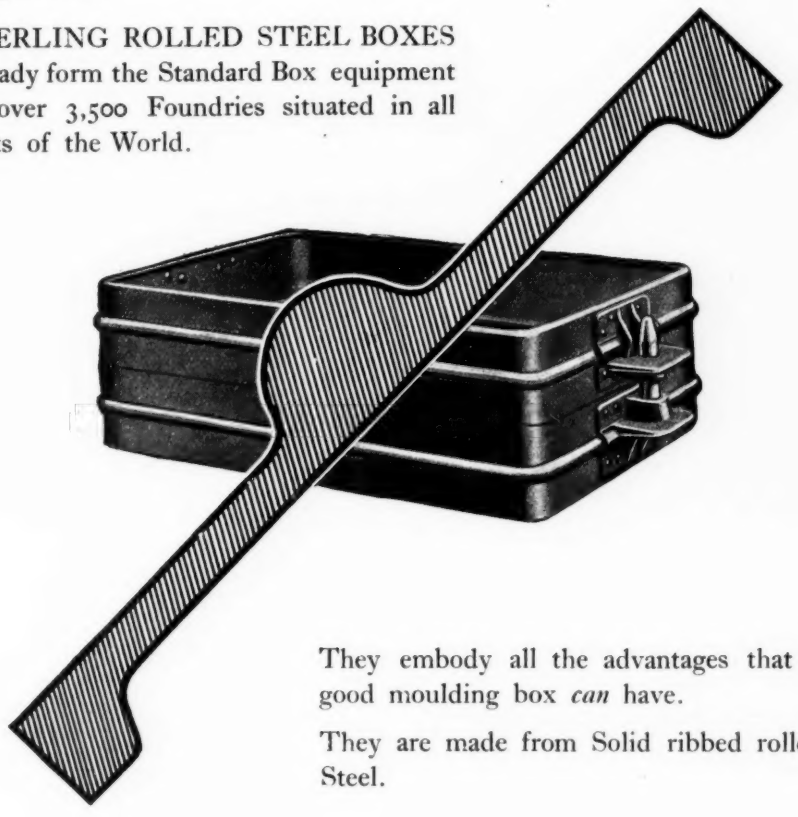

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Three months ..	59	2	6
Electrolytic	66	10	0
Tough	64	10	0
Best selected ..	65	0	0
Sheets	92	0	0
India	75	0	0
Wire bars ..	67	0	0
Do. November ..	66	17	6
Do. December ..	66	17	6
Ingot bars	66	17	6
H.C. wire rods ..	70	15	0
Off. av. cash, Sept.	58	15	4 1/16
Do., 3 mths. Sept.	59	10	4 1/16
Do., Sttlmnt, Sept.	58	15	0
Do., Electro. Sept.	66	14	6 5/16
Do., B.S., Sept. ..	65	9	4½
Aver. spot price copper, Sept. ..	58	15	0
Do.,wire bars, Sept.	66	18	6½
Solid drawn tubes			13d.
Brazed tubes ..			13d.
Wire			9½d.

BRASS.

Solid drawn tubes ..	12d.
Brazed tubes	13½d.
Rods, drawn	11½d.
Rods, extd. or rlld. ..	7½d.
Sheets to 10 w.g ..	10½d.
Wire	10½d.
Rolled metal	9¾d.
Yellow metal rods ..	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets ..	8¼d.

TIN.

	£	s.	d.
Standard cash ..	311	5	0
Three months ..	302	10	0
English	309	5	0
Bars	314	10	0
Straits	322	0	0
Australian	—		
Eastern	311	10	0
Banca	—		
Off. avr. cash, Sept.	306	8	9
Do., 3 mths. Sept.	298	5	7½
Do., Sttlmt. Sept.	306	7	0 5/16
Aver. spot., Sept.	306	8	9

SPELTER.

Ordinary	34	5	0
Remelted	33	0	0
Hard	28	0	0
Electro 99.9 ..	37	0	0
English	35	0	0
India	30	10	0
Zinc dust	43	0	0
Zinc ashes	16	0	0
Off. aver., Sept. ..	34	8	0 11/16
Aver., spot, Sept.	34	7	9½

LEAD.

Soft foreign ppt.	30	12	6
English	32	0	0
Off. average, Sept.	31	18	9
Average spot, Sept.	32	1	8 5/16

ZINC SHEETS, &c.

Zinc sheets, English	42	15	0
Do. V.M. ex whf.	39	15	0
Rods	45	0	0
Boiler plates ..	39	0	0
Battery plates ..	38	10	0

ANTIMONY.

Special brands, Eng.	74	10	0
Chinese	60	0	0
Crude	40	0	0

QUICKSILVER.

Quicksilver ..	16	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon	
25%	9 2 6
45/50%	10 5 0
75%..	16 0 0
Ferro-vanadium—	
35/40%	14/6 to 14/9 lb. va.
Ferro-molybdenum—	
70/75% c. free ..	5/3 lb.
Ferro-titanium—	
23/25 % carbonless	11½d.
Ferro-phosphorus,	20/25%, £17 0 0
Ferro-tungsten—	
80/85%,c.fr. ..	1 4½ lb.
Tungsten metal powder—	
98/99%	1/9 to 1/10 lb.
Ferro-chrome—	
2/4% car. ..	£33 0 0
4/6% car. ..	£23 0 0
6/8% car. ..	£21 15 0
8/10% car. ..	£20 15 0
Ferro-chrome—	
Max. 2% car.	£37 0 0
Max. 1% car.	£43 5 0
Max.0.70%car.	£54 0 0
70%,carbonless	1/5 lb.
Nickel—99%, cubes or pellets ..	£170
Cobalt metal—98/99%	10/- lb.
Aluminium 98/99%	£107 to £112
Metallic Chromium—	
96/98% ..	3/- lb.
Ferro-manganese (net)—	
76/80%, loose	£15 0 0
76/80%, packed	£16 0 0
76/80%, export	£15 0 0
Metallic manganese—	
94/96%, carbonless	2/- lb.
Per ton unless otherwise stated.	

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten ..	2	6
Finished bars, 18% tungsten ..	3	0
Per lb. net, d/d buyers' works.		
Extras—		
Rounds and squares 3 in. and over ..	4d. lb.	
Rounds and squares under ½ in. to ¼ in.	3d. lb.	
Do. under ¼in. to ⅛ in.	1/- lb.	
Flats, ½in. × ¼in. to under 1 in. × ¾ in.	3d. lb.	
Do. under ½in. × ¼in.	1/- lb	
Bevels of approved sizes and sections	6d. lb.	
Bars cut to length	10% extra	
Scrap from high-speed tool steel—		
Scrap pieces	3d.	
Turnings and swarf	1d.	
Per lb. net, d/d steel makers' works.		

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Hvy. steel	2	12	6 to	3	0	0
Bundled steel & shrngs.	2	5	0 to	2	7	6
Mixed iron & steel	2	5	0 to	2	12	6
Heavy cast iron	2	15	0 to	3	0	0
Good machinery for foundries	2	17	6 to	3	5	0
Cleveland—						
Heavy steel ..		3	0	0		
Steel turnings ..		2	7	6		
Cast iron borings		2	5	0		
Heavy forge ..		4	2	6		
Bushelled scrap		3	10	0		
Cast-iron scrap	3	8	0 to	3	10	0
Lancashire—						
Cast-iron scrap	3	7	6 to	3	10	0
Hvy. wrought ..		3	2	6		
Steel turnings ..		2	2	0		
London — Merchants' buying prices delivered yard.						
Copper (clean)..		48	0	0		
Brass (clean) ..		37	0	0		
Lead (less usual draft)		27	10	0		
Tea lead ..		23	0	0		
Zinc		23	0	0		
New aluminium cuttings ..		82	0	0		
Braziery copper		44	0	0		
Gunmetal ..		46	0	0		
Hollow pewter		200	0	0		
Shaped black pewter ..		150	0	0		

PIG-IRON.

(f.o.t. unless otherwise stated).

N.E. Coast –	
Foundry No. 1 ..	125/-
Foundry No. 3 ..	120/-
Foundry No. 4 ..	119/-
Forge No. 4	118 6
Hematite No. 1 ..	88/-
Hematite M/Nos. ..	87/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	88 6
„ d/d Birm	107/6 to 115/-
Midlands—	
Staffs common* ..	—
„ No. 4 forge ..	—
„ No. 3 foundry	—
Shrops. basic	—
„ Cold blast, ord.*	—
„ „ roll iron* ..	—
* d/d Birmingham.	
Northants forge	—
„ fdry No. 3 ..	—
Derbyshire forge ..	—
„ fdry. No. 3 ..	—
„ basic	—
Scotland—	
Foundry No. 1 ..	—
„ No. 3 ..	105/-
Hem. M/Nos. ..	—
Sheffield (d/d district)—	
Derby forge	—
„ fdry. No. 3 ..	—
Lincs. forge	—
„ fdry. No. 3 ..	—
E.C. hematite	—
W.C. hematite ..	95/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3.. ..	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
„ fdry. No. 3 ..	—
Northants foundry No. 3	—
Dalzell, No. 3	125/-
Summerlee, No. 3 ..	125/-
Glengarnock, No. 3 ..	125/-
Gartsherrie, No. 3 ..	125/-
Monkland No 3	125/-
Coltness, No. 3	125/-
Shotts, No. 3	125/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.	£	s.	d.
Iron—						
Bars (cr.) nom. ..	12	0	0 to	13	10	0
Angles				12	0	0
Tees to 3 united ins.				12	10	0
Nut and bolt iron				—		
Hoops				14	10	0
Marked bars (Staffs.) f.o.t. ..				14	0	0
Gas strip				12	10	0
Bolts and nuts .. ¾ in. × 4 in. ..				15	5	0
Steel—						
Ship plates				8	12	6
Boiler plts. ..				11	5	0
Chequer plts. ..				9	10	0
Angles				7	12	6
Tees				8	12	6
Joists				7	12	6
Rounds and Squares 3 in. to 5½ ins. ..				9	0	0
Rounds under 3 in. to ¾ in.				8	12	6
Flats, over 5 in. wide and up ..				9	10	0
Flats, 5in. to 1½in.				8	10	0
Rails, heavy ..				8	10	0
Fishplates				12	10	0
Hoops (Staffs.) ..				10	10	0
Black sheets, 24g.				11	17	6
Galv. cor. sheets, 24g.	16	10	0 to	16	15	0
Galv. fencing wire 8g. plain				12	10	0
Billets, soft ..				7	15	0
Billets, hard				8	2	6
Sheet bars	7	0	0 to	7	10	0
Tin bars d/d	7	0	0 to	7	10	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3½
Wire	1	4
Rods	1	3
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb. basis.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks ..	9d. to 1/5½
Ingots rolled to spoon size ..	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	20.26
No. 2 foundry, Birm.	20.00
Basic	19.76
Bessemer	20.76
Malleable	20.26
Grey forge	19.76
Ferro-mang. 80% d/d	88.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	2.00
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.50
Sheets, black, No. 24..	3.00
Sheets, galv., No. 24 ..	3.85
Sheets, blue an'l'd, 9 & 10	2.30
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry	—
„ furnace	—
Durham & North.	
„ foundry	—
„ furnace	57/6
Other Districts, foundry	—
„ „ furnace (basis)	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	22/-
„	28×20, „	44/-
„	20×10, „	—
„	18¾×14, „	—
C.W.	20×14, „	—
„	28×20, „	—
„	20×10, „	—
„	18¾×14, „	—

Terneplates 28×20, — per box basis f.o.b.

SWEDISH IRON.

Bars,hammered	£18/10 to £19/0
Rolled Ord.	£15/10/0 to £16
Nail rods	£16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£9 to £12
Pig-iron	£6 0 0 to £6 10 0

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes	*Fittings*
Gas	60%	50%
Water	55%	45%
Steam	50%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.		
Oct. 14	59	7	6	inc.	10/-
,, 15	59	7	6	No change	
,, 18	58	17	6	dec.	10/-
,, 19	58	15	0	,,	2/6
,, 20	58	5	0	,,	10/-

Electrolytic Copper.

	£	s.	d.		
Oct. 14	66	10	0	No change	
,, 15	66	10	0	,,	,,
,, 18	66	10	0	,,	,,
,, 19	66	10	0	,,	,,
,, 20	66	10	0	,,	,,

Standard Tin (Cash).

	£	s.	d.		
Oct. 14	318	15	0	inc.	130/-
,, 15	321	0	0	inc.	45/-
,, 18	315	0	0	dec.	120/-
,, 19	314	10	0	,,	10/-
,, 20	311	5	0	,,	65/-

Tin (English ingots).

	£	s.	d.		
Oct. 14	316	15	0	inc.	125/-
,, 15	319	0	0	,,	45/-
,, 18	313	0	0	dec.	120/-
,, 19	312	10	0	,,	10/-
,, 20	309	5	0	,,	65/-

Zinc Sheets (English).

	£	s.	d.		
Oct. 14	42	15	0	No change	
,, 15	42	15	0	,,	,,
,, 18	42	15	0	,,	,,
,, 19	42	15	0	,,	,,
,, 20	42	15	0	,,	,,

Spelter (ordinary).

	£	s.	d.		
Oct. 14	34	10	0	inc.	6 3
,, 15	34	12	6	,,	2/6
,, 18	34	8	9	dec.	3/9
,, 19	34	8	9	No change	
,, 20	34	5	0	dec.	3/9

Lead (English)

	£	s.	d.		
Oct. 14	32	10	0	inc.	10/-
,, 15	33	0	0	,,	10/-
,, 18	32	10	0	dec.	10/-
,, 19	32	5	0	,,	5/-
,, 20	32	0	0	,,	5/-

Exports of Iron Castings in September and the nine months 1926, compared with September and the nine months 1925.

	September, 1925.	September, 1926.	Nine months, 1925.	Nine months, 1926.	September, 1925.	September, 1926.	Nine months, 1925.	Nine months, 1926.
BUILDERS' CASTINGS—	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Stoves, Grates, etc., Cisterns, Baths, etc., and cooking and washing boilers—								
To Argentine Republic	138	160	1,182	1,088	4,334	5,693	42,868	45,079
,, British South Africa	307	349	2,763	3,261	10,732	11,624	97,365	110,755
,, ,, East Indies	118	177	1,299	1,349	4,956	7,083	59,499	58,789
,, Australia	42	64	525	656	2,316	4,013	29,539	36,846
,, New Zealand	158	222	2,027	1,761	8,415	11,522	94,614	85,840
,, Other countries	724	712	5,828	6,039	37,071	37,649	294,783	291,483
Total	1,487	1,684	13,624	14,154	67,824	77,584	618,659	628,792
PIPES AND FITTINGS—CAST—								
To Argentine Republic	726	1,011	9,128	6,628	10,218	11,089	117,385	80,713
,, British South Africa	342	345	5,197	5,773	5,514	7,294	74,305	80,264
,, ,, India	637	411	7,391	6,461	9,934	7,178	105,504	83,496
,, Straits Settlements and Malay States	231	785	4,455	13,511	2,794	8,491	53,086	116,202
,, Ceylon	96	32	997	1,561	1,107	519	12,422	17,812
,, Australia	186	59	2,415	3,092	3,798	2,384	39,018	42,454
Other countries	4,540	2,307	42,180	35,677	67,828	38,165	620,291	498,423
Total	6,758	4,950	71,763	72,703	101,193	75,120	1,022,011	919,364
HOLLOW-WARE—								
Cast, not Enamelled, and Cast, Tinned	696	459	6,162	4,982	24,403	14,842	207,465	174,161
,, Enamelled	70	105	749	740	7,450	12,267	77,300	79,190
CASTINGS, in the rough—								
Iron	50	56	1,120	1,108	2,147	1,993	39,349	31,200
Steel	83	26	557	549	3,307	1,369	22,722	16,736

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

18, BENNETTS HILL, BIRMINGHAM.
11, OLD HALL STREET, LIVERPOOL.
EXCHANGE BLDGS., PORT TALBOT.
FOWLERS BUILDINGS, BOMBAY.
CLIVE STREET, CALCUTTA.
ANGAPPA NAICK STREET, MADRAS.

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1, HONG KONG ROAD, SHANGHAI.
OCEAN BUILDING, SINGAPORE.
JAVA STREET, KUALA LUMPUR
5, SHAFFRAZ ROAD, RANGOON.
COX'S BUILDINGS, KARACHI.
P.O. BOX 1580, CAIRO.

PIG IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.,

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE

WILLIAM JACKS & COMPANY,

19, ST. VINCENT PLACE, GLASGOW.

ZETLAND ROAD, MIDDLESBROUGH.

SMALL ADVERTISEMENTS.

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SITUATIONS VACANT AND WANTED.

FOUNDRY SUPT. AND MOULDING MACHINE PRODUCTION EXPERT desires position; able to get excellent results from machines considered failures; trained Metallurgist; keen and energetic organiser.—Box 814, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY MANAGER DESIRES RE-ENGAGEMENT; experienced man in all branches of Foundry work; accustomed to large output of General Engineering, Electrical, Machine Tool, Wood-working Machinery, Internal-combustion Engines, Marine Engineering and Textile work; experienced in Plate, Machine and Repetition work; expert in Cupola practice; Semi-steel a speciality; many years' experience as representative and well known to buyers of Castings; good organiser and control; eighteen years' experience as foreman and manager; 44 years of age.—Box 840, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

REPRESENTATIVES required for large firm of Foundry Plant Manufacturers; part expenses and good commission given to the right type of Representative who can influence business. State full particulars and area covered.—Box 842, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

AGENCIES.

AUSTRALIAN IMPORT AND EXPORT MERCHANTS desire Agencies for Australia from British firms; special lines: Iron and Steel Manufactured Goods.—Reply Clemons & Co., Chartered Accountants, 55-6, Chancery Lane, W.C.2.

FINANCIAL.

WANTED, an Engineering Firm using a fair amount of Iron Castings, to take an interest in an Iron Foundry casting from 30 cwts. to 2 tons daily.—Apply, Box 832, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

PATENTS.

THE OWNERS of British Patent No. 216580 entitled "An Improved Process for Extracting Tin from Its Ores," No. 220012 entitled "Process of Electrolytically Refining Tin Bullion," No. 219719 entitled "Process of Producing Metallic Tin," and No. 176080 entitled "Improvements in Power Driven Load Carrying Trucks," desire to dispose of the same or would grant a licence to work the Inventions or royalty terms.—Particulars may be obtained from Technical Records, Ltd., of 59-60, Lincoln's Inn Fields, London, W.C.2.

PATENT YOUR INVENTIONS, Trade-mark your Goods. Advice, Handbook and Cons. free.—B. T. King, C.I.M.E. (Regd. Pat. Agent, G.B., U.S.A., and Can.). 146a, Queen Victoria Street, E.C.4. 38 years' refs. 'Phone 682 Central.

MACHINERY.

SAND MIXERS.—New and second-hand. Ask us to quote.—W. Brealey & Company, Limited, Prospect Works, Hawksley Avenue, Sheffield.

WANTED, one Portable Electrical Sand Riddle; "Champion" type or similar; suitable for 400 v., 3 p., 50 cyc.—Box 844, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

New 5-ton GEARED CRANE LADLE, by McNeil, Glasgow £40 0 0
DROP-BOTTOM FURNACE, 2 ft. 6 in. dia., complete
No. 1 ROOTS BLOWERS AND PIPES, by Allday & Onions £55 0 0
COLD CIRCULAR SAW, 2 ft. 6 in. traverse, new condition, by Clifton & Waddell £55 0 0
—Box 846, Offices of the Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

MACHINERY.—*Continued.*

MACHINERY, PLANT, &c.

Five-ton "Wilson" LOCO. STEAM SHUNTING CRANE, having 35-ft. steel jib, 4 ft. 8½-in. gauge; all motions; two hoisting speeds; 100 lbs. boiler.

Three-ton "Smith" LOCO. STEAM CRANE, having 30-ft. jib; 4 ft. 8½ in. gauge; all motions; 100 lbs. boiler.

HORIZONTAL STEAM-DRIVEN AIR COMPRESSOR, 14 in. steam cyl., 14 in. air cyl., 16 in. stroke.

MOTOR-DRIVEN "SENTINEL" AIR COMPRESSOR, 260 cubic ft. capacity, 55 h.p. motor, D.C., 500 volts.

Two BELT-DRIVEN SINGLE-STAGE QUADRUPLEX AIR COMPRESSORS, 300 cubic ft. capacity at 80/100 lbs.

LANCASHIRE BOILER, 30 ft. x 8 ft. 6 in. diamr.; reinsure 100 lbs. pressure.

CATALOGUE (10,000 Lots) ON APPLICATION.

THOs W. WARD, LTD.,
ALBION WORKS, SHEFFIELD.

ONE 15-TON BOTTOM-POURING LADLE, complete with Tipping Gear; maker, Stevensons; absolutely new and in perfect condition; can be seen any time; very cheap.—Apply Box 836, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

MISCELLANEOUS.

PATTERNS.—Inquiries solicited; quotations by return; shop equipped with modern machinery; quick delivery.—Cleghorn & Company, Midland Pattern Works, Spring Gardens, Worcester. Phone 264.

ALL FOUNDRY SUPPLIES.—You are guaranteed the best service and quick deliveries when you submit your requisitions to Lawson Walton & Co., Ltd., Newcastle-on-Tyne.

RED IRON-OXIDE PAINTS, ready for use; the best paint for Iron Works; cwt., 27s. 6d.; 4-cwt. lots at 25s., carriage paid.—William Olsen, Limited, Cogan Street, Hull.

LARGE quantities of Solid High-speed Steel Scrap, guaranteed minimum 16 per cent. Tungsten, REQUIRED.—Submit offers, together with full particulars and sample, to Box 838, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY REQUISITES

Try our REFRACTORIES.

Ganister or Silica Bricks and Blocks (any shape or size).
Sands, Cements, Ganister.—*Let us have your enquiries.*

THE CLEVELAND MAGNESITE & REFRACTORY CO., LTD.,
Normanby Brickworks, Normanby, Eston, Yorks.

ERITH LOAM
J. PARISH & CO.,
ERITH.

WORM & BEVEL GEARED CRANE LADLES

NEW ½ ton, enclosed Gears, latest type	£13
NEW 1 ton, enclosed Gears, latest type	£20
NEW 2 ton, by Thwaites	£25
NEW 2½ ton, by Geo. Green	£30
3½ ton, by Stevensons	£30
5 ton, by James Evans & Co.	£45
12 ton, by James Evans & Co.	£75

LARGEST STOCK OF FOUNDRY PLANT IN ENGLAND

BUY FROM ME AND SAVE MONEY.

ALEX. HAMMOND, *FOUNDRY MACHINERY MERCHANT,*
14, AUSTRALIA ROAD, SLOUGH.